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Tsuritani et al.

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(45) **Date of Patent: May 23, 2017**

(54) **POWDER CONTAINER, DEVELOPING DEVICE, PROCESS UNIT, AND IMAGE FORMING APPARATUS**

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G03G 15/08 (2006.01)

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See application file for complete search history.

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Primary Examiner — David Gray
Assistant Examiner — Carla Therrien
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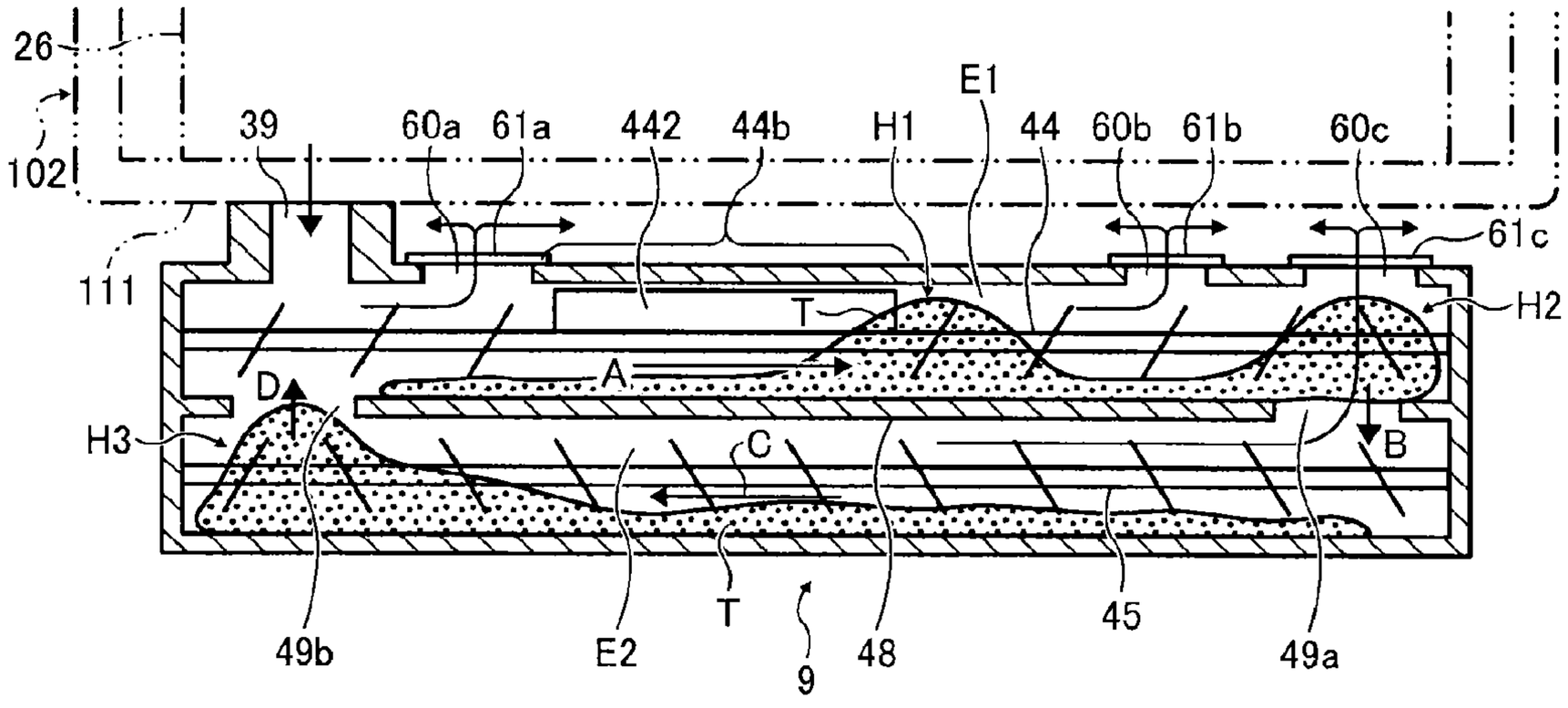
(57) **ABSTRACT**

A powder container is provided. The powder container includes a powder storage and a conveyer. The powder storage stores a powder to be used for image formation and has a vent hole to pass air between an inside and an outside of the powder storage. The conveyer conveys the powder inside the powder storage. The vent hole is on an upper surface of the powder storage facing the conveyer.

20 Claims, 12 Drawing Sheets



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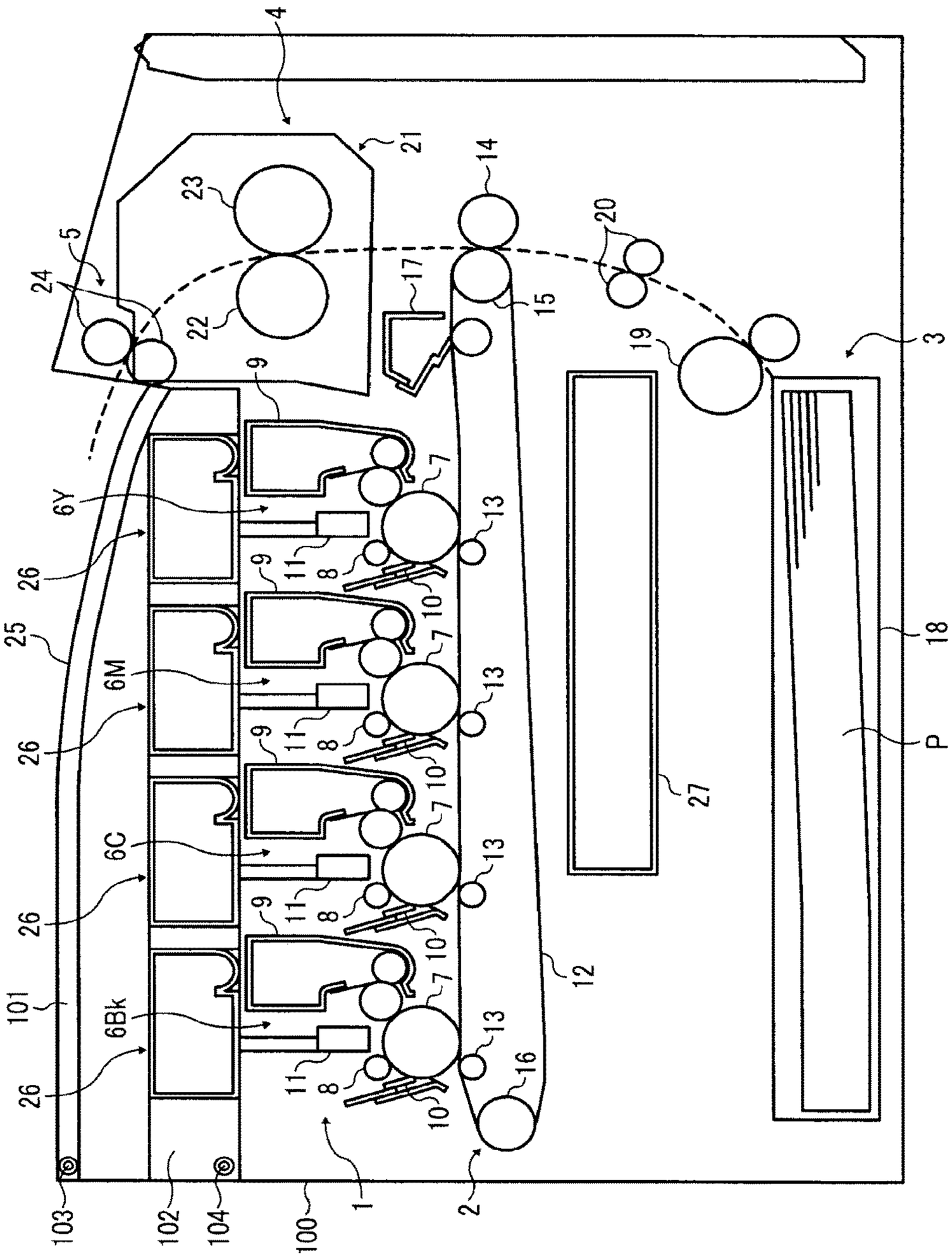

4
21
14
23
20
5
24
17
22
15
19
3
9
7
6Y
13
26
11
8
10
25
6M
18
P
27
6C
12
101
6Bk
16
103
102
104
100
1
2

FIG. 1

FIG. 2

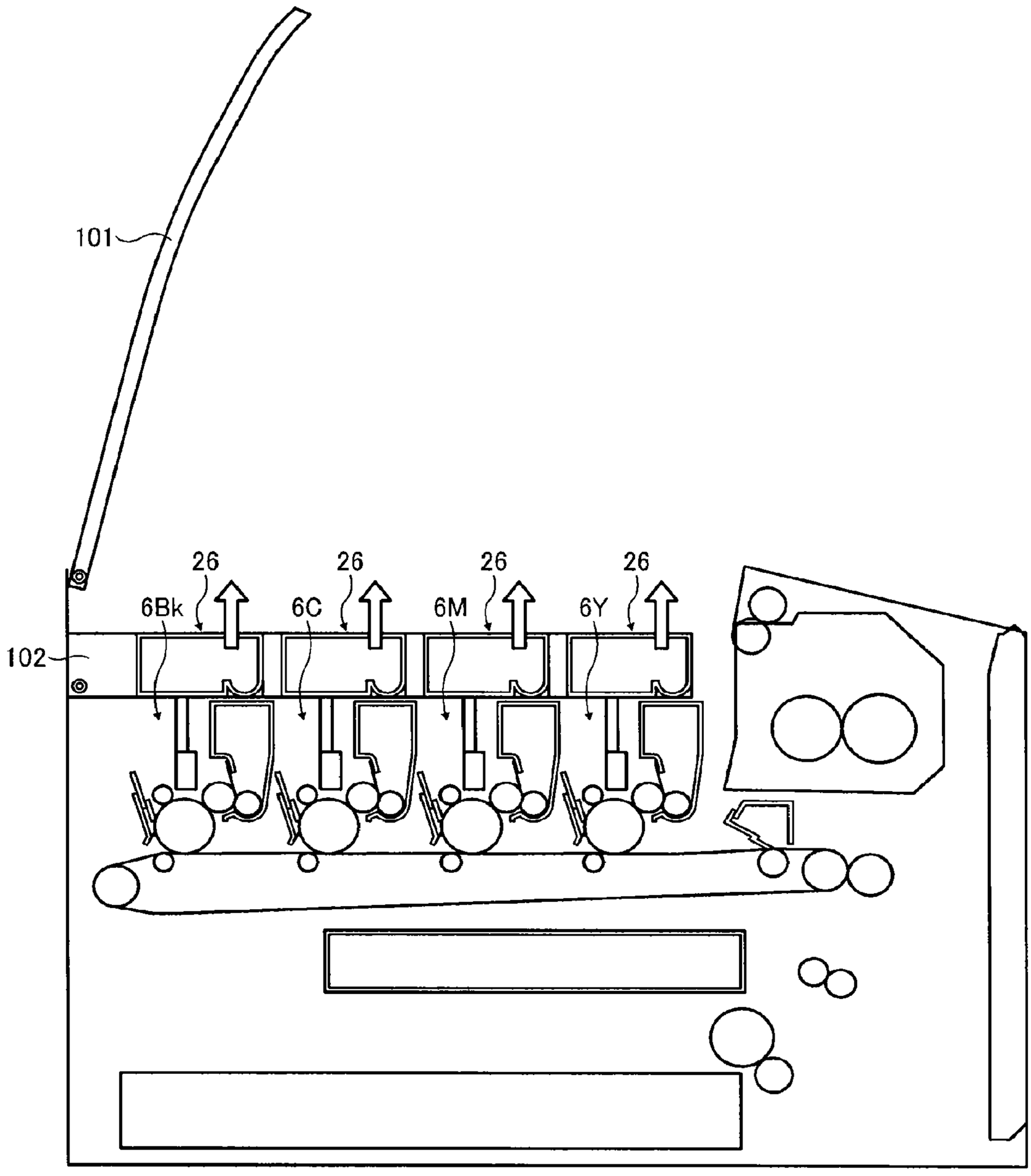


FIG. 3

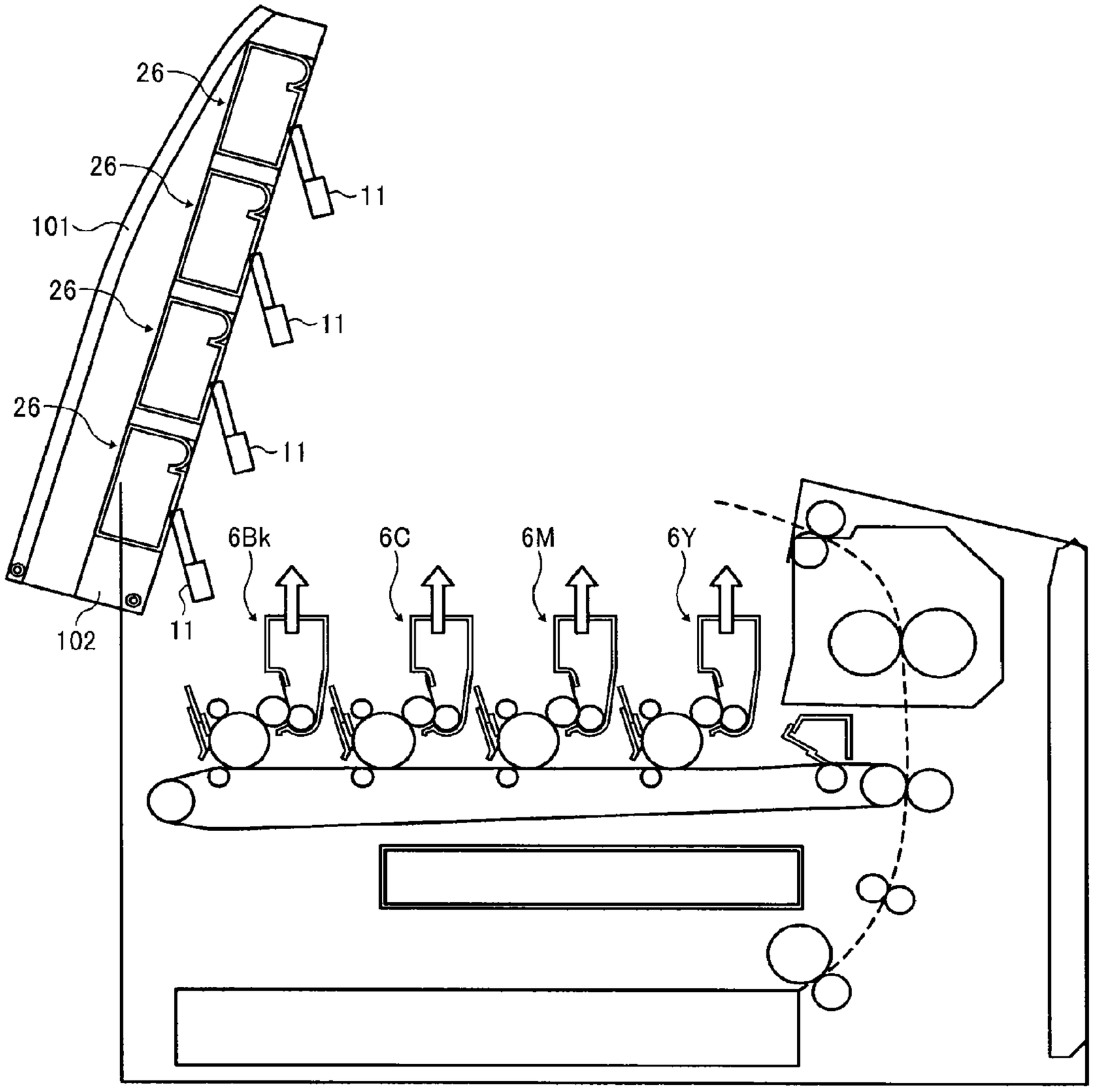


FIG. 4

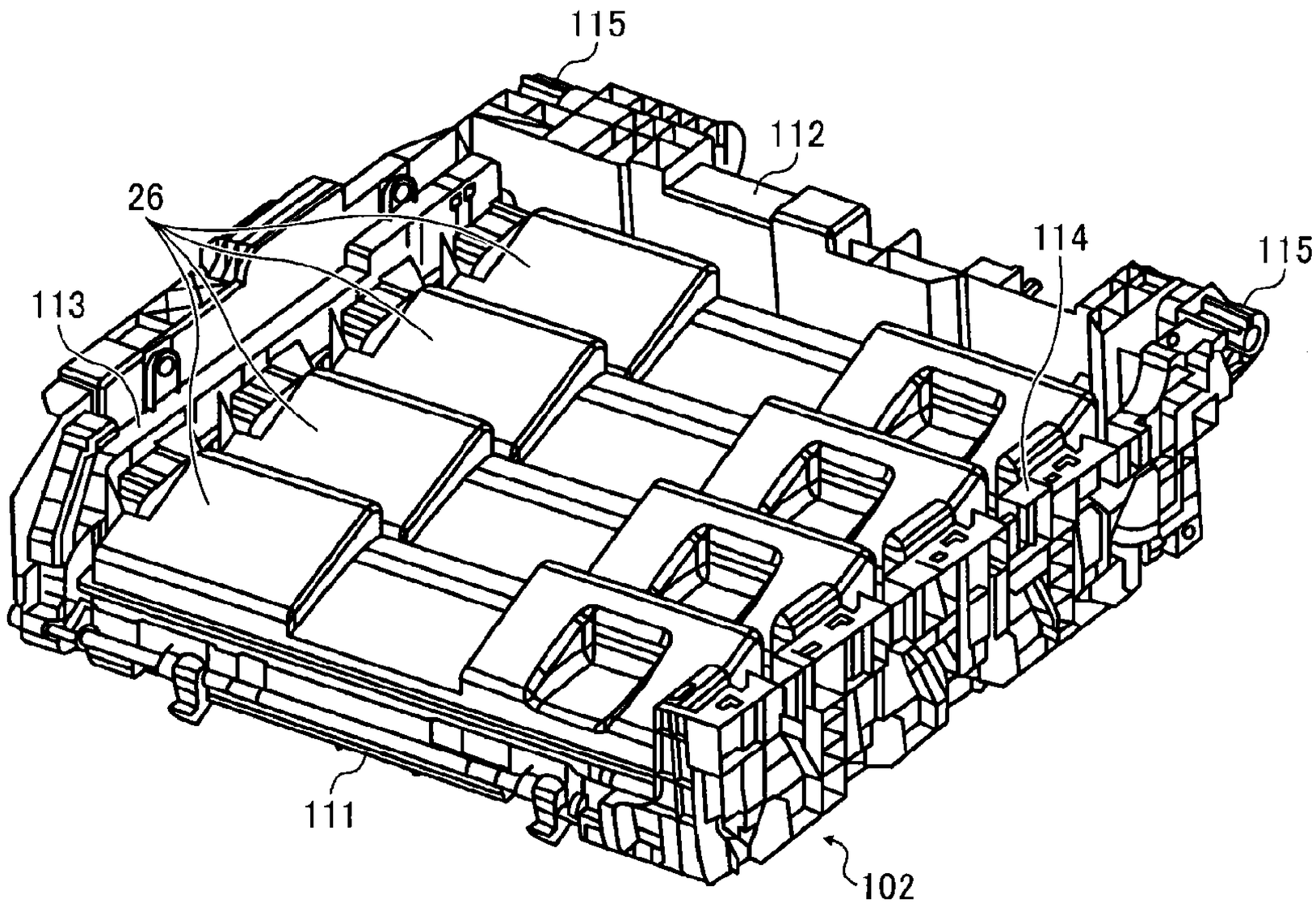


FIG. 5

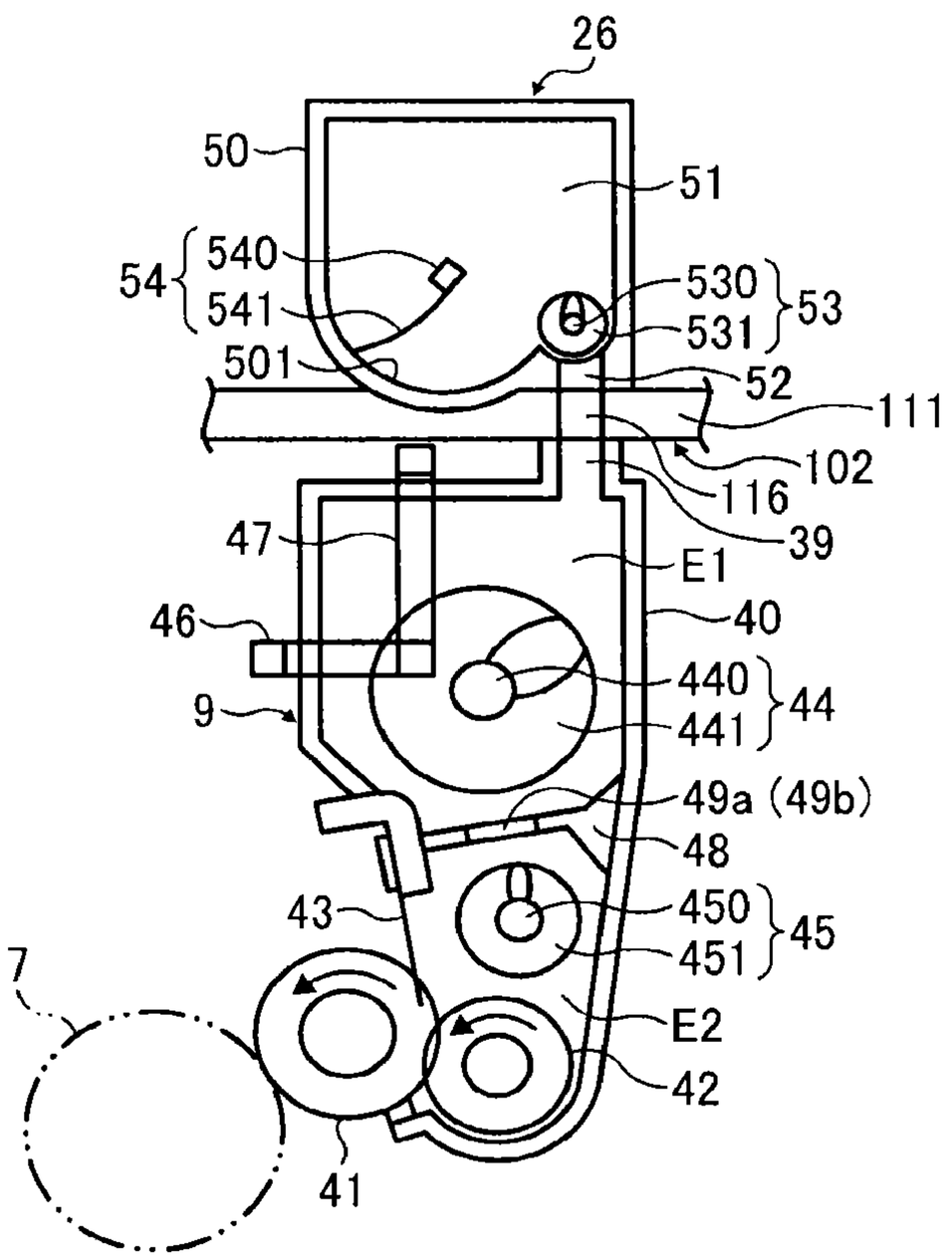

26
50
51
54
540
541
530
531
53
501
52
111
102
116
39
47
E1
46
40
440
441
44
9
49a (49b)
48
43
450
451
45
7
E2
42
41

FIG. 6
RELATED ART

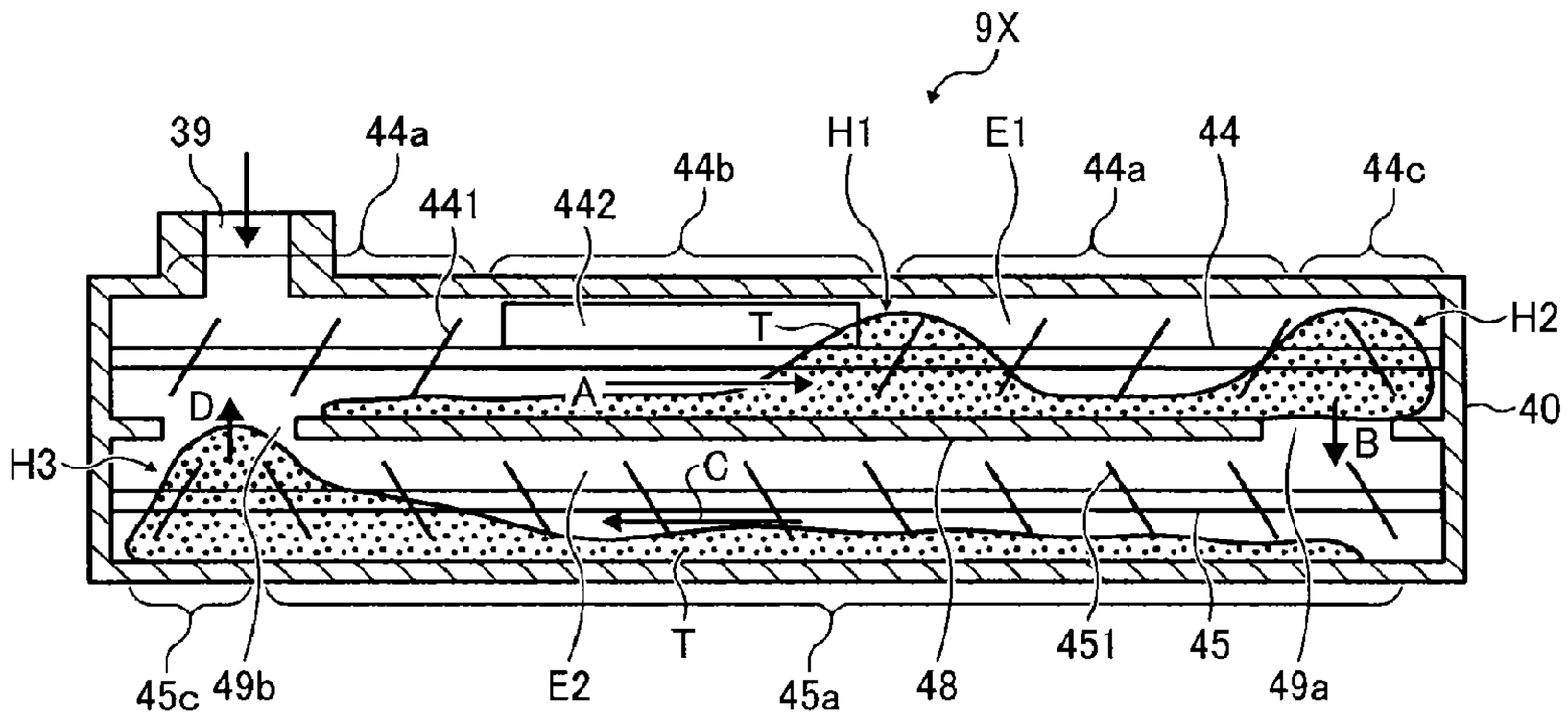


FIG. 7

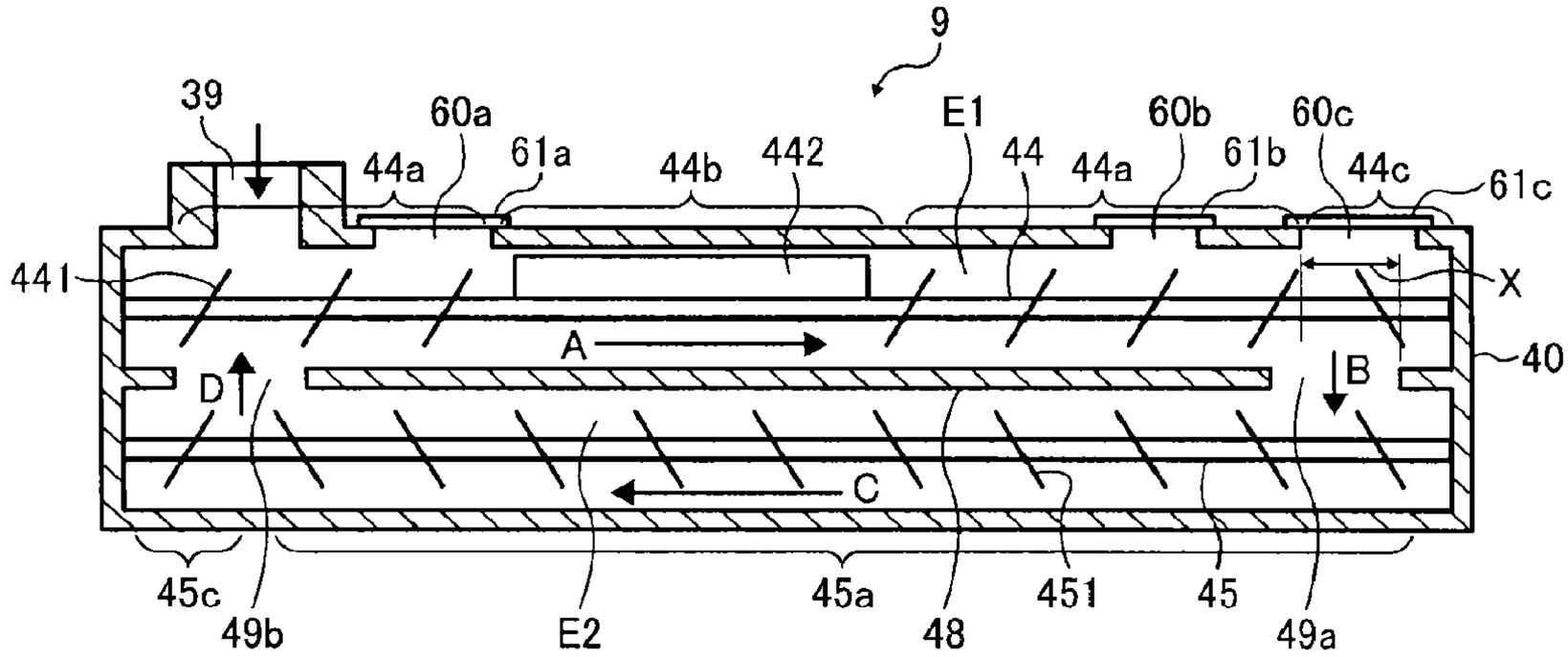


FIG. 8

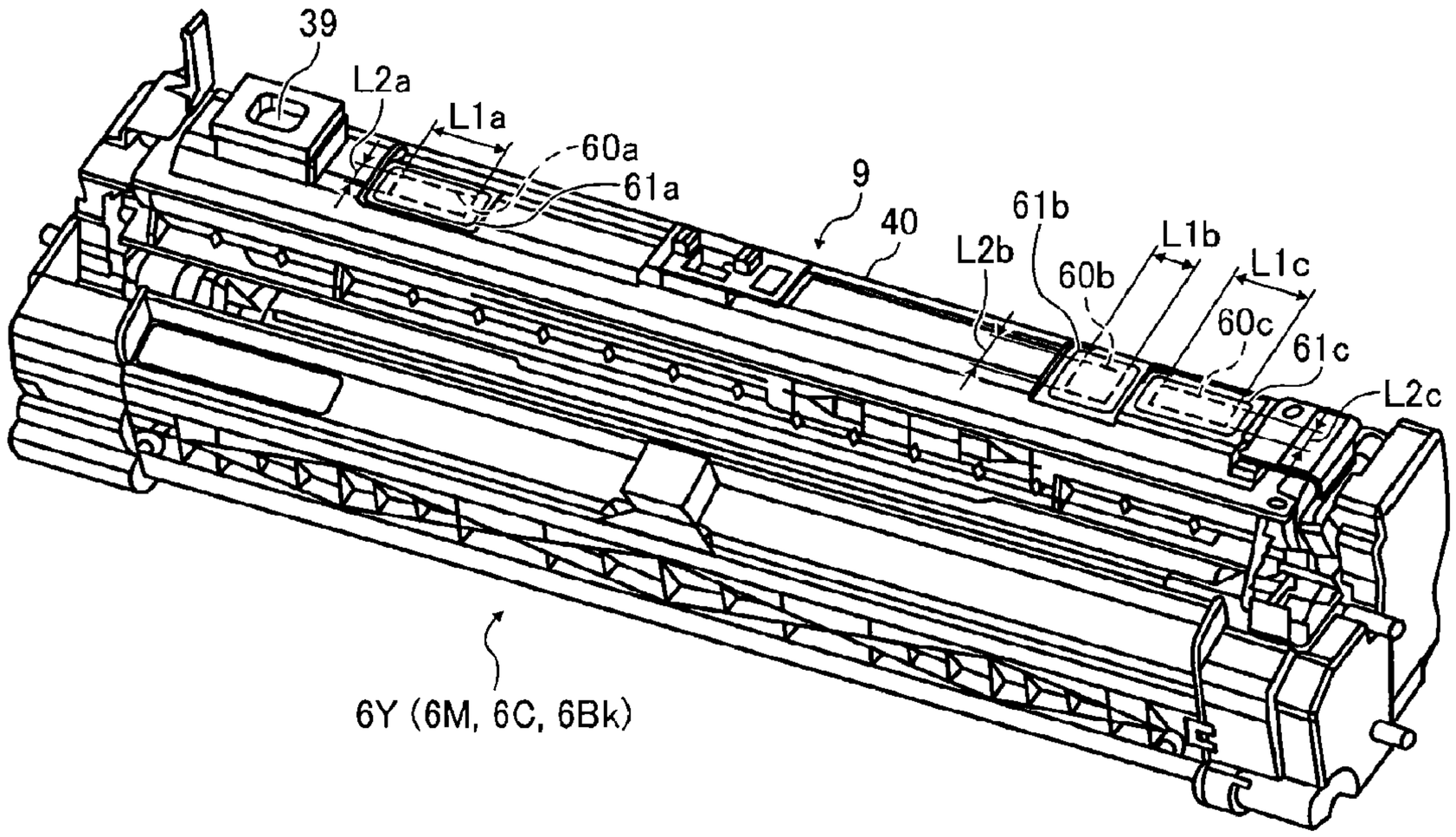
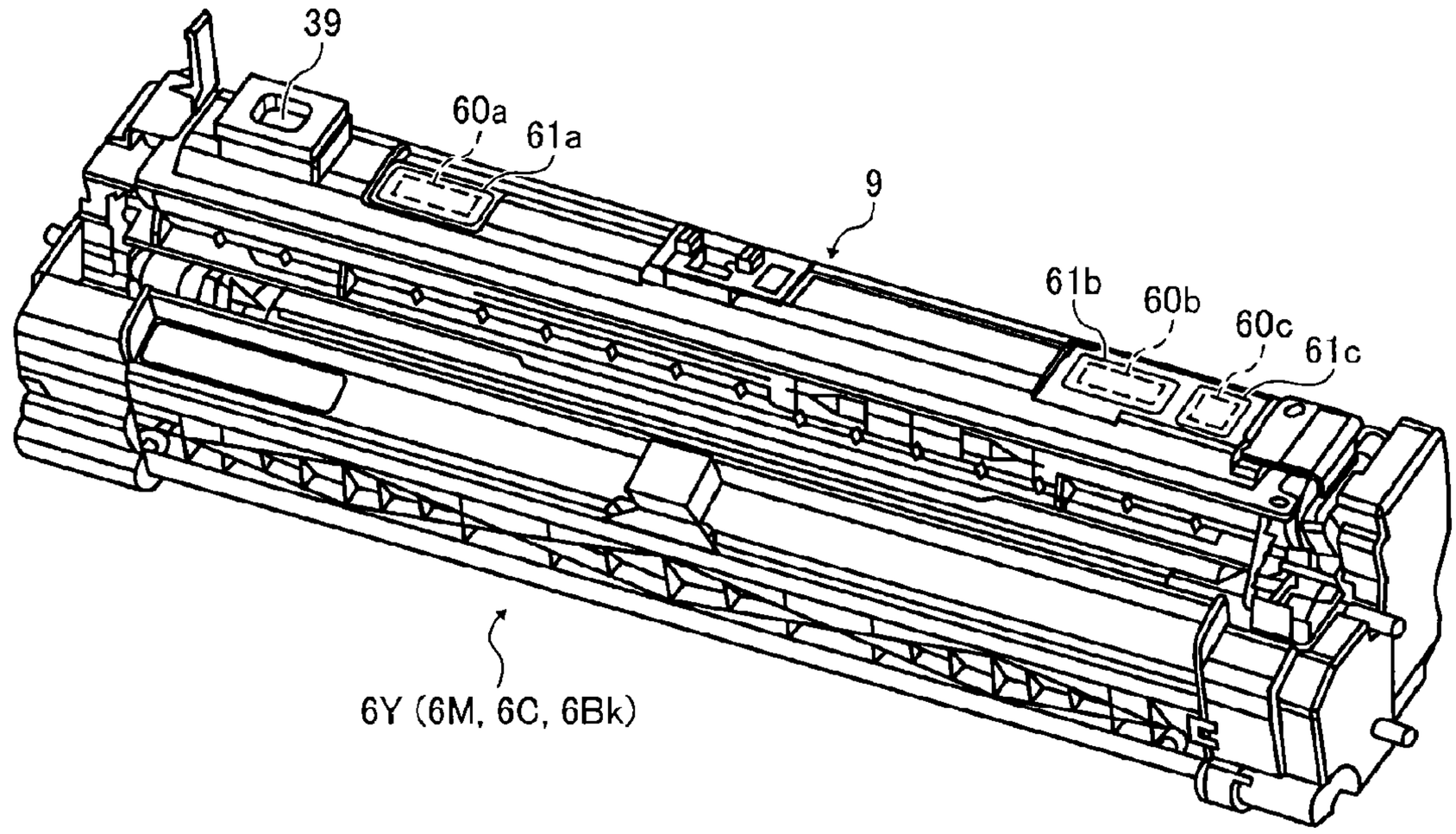

39
L2a
L1a
60a
61a
9
40
61b
L2b
60b
L1b
L1c
60c
61c
L2c
6Y (6M, 6C, 6Bk)

FIG. 9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9
61b
60b
60c
61c
6Y (6M, 6C, 6Bk)

FIG. 10

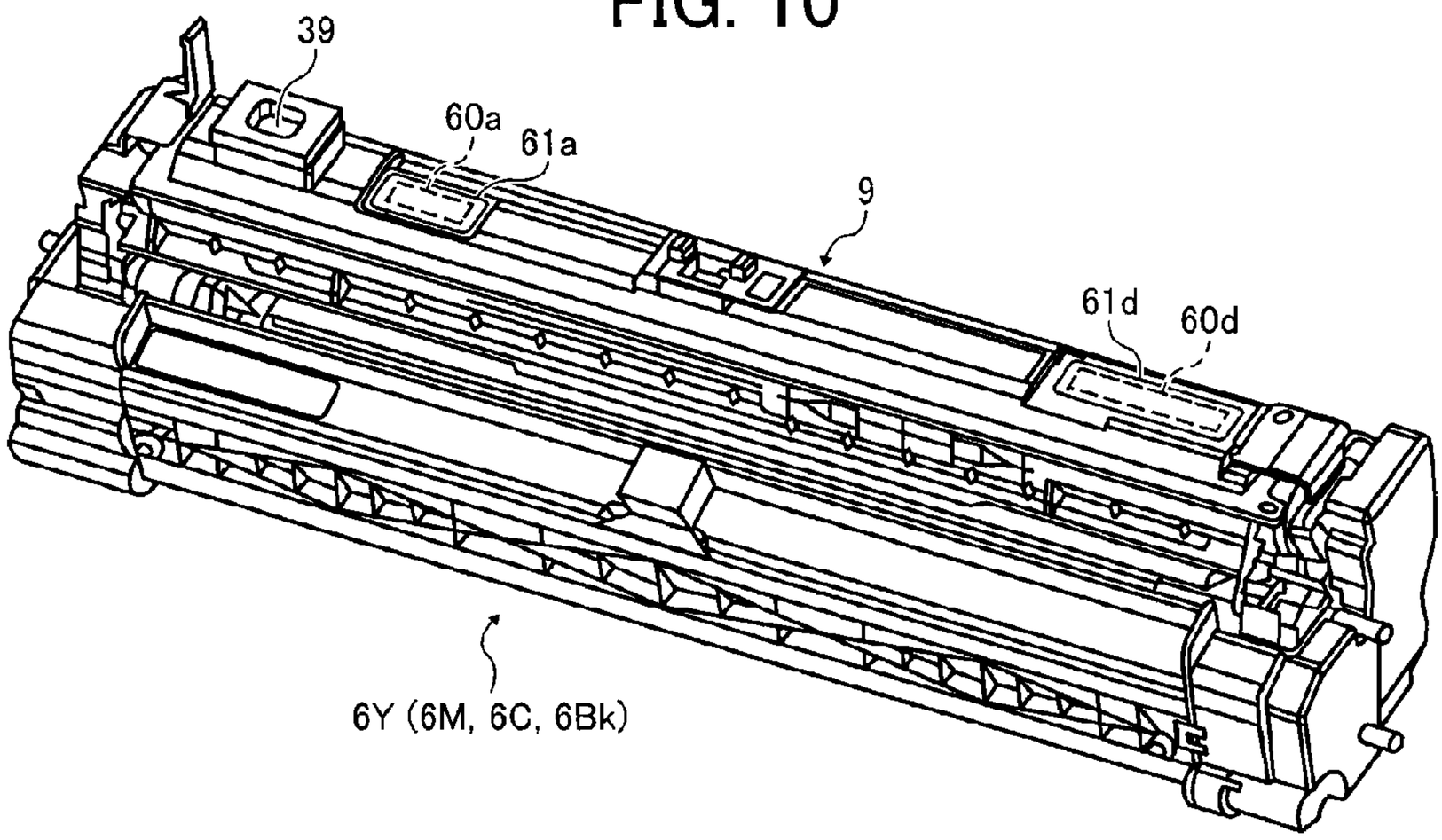


FIG. 11A

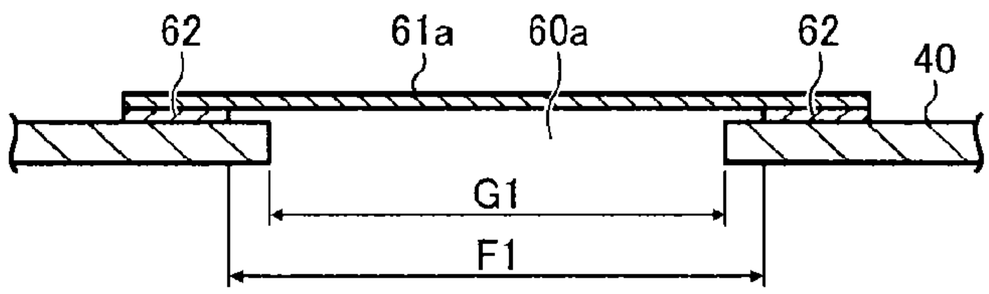


FIG. 11B

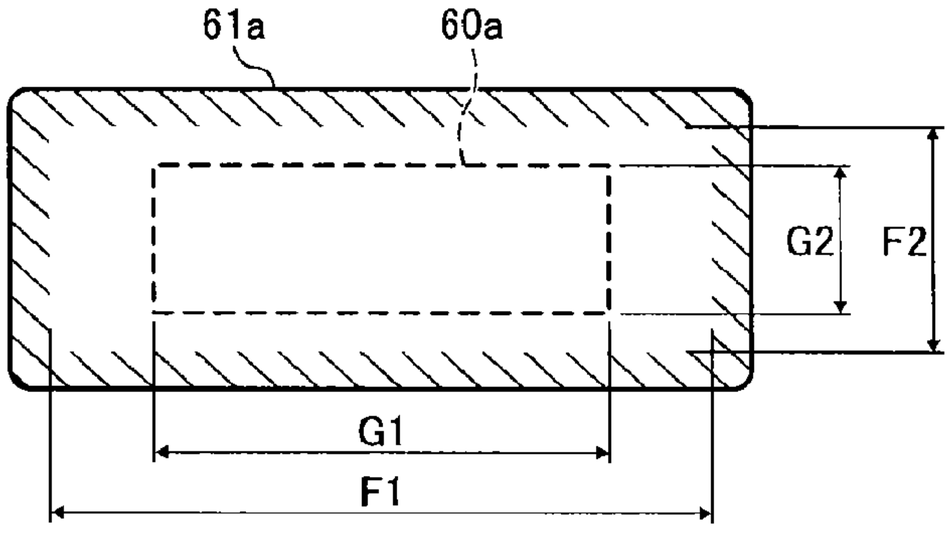
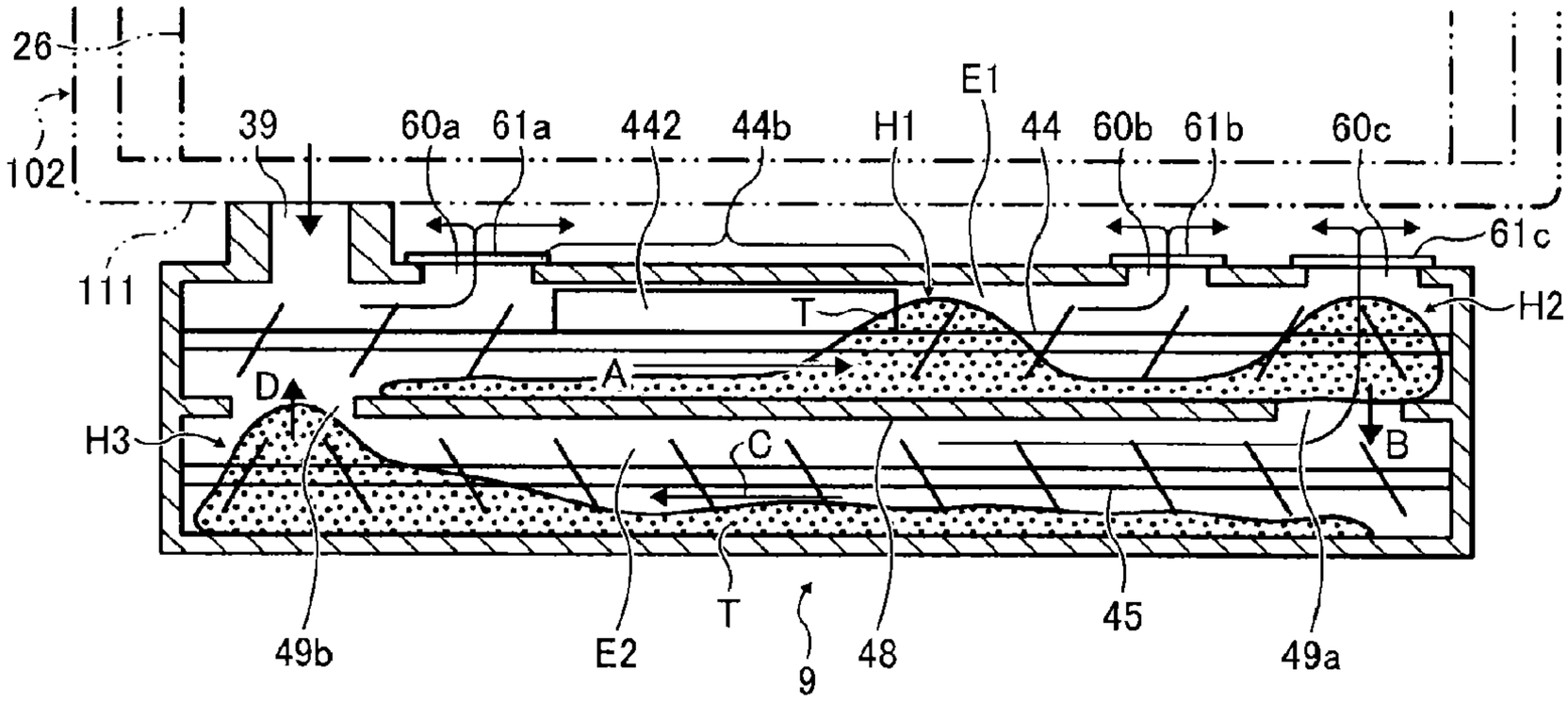


FIG. 12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111
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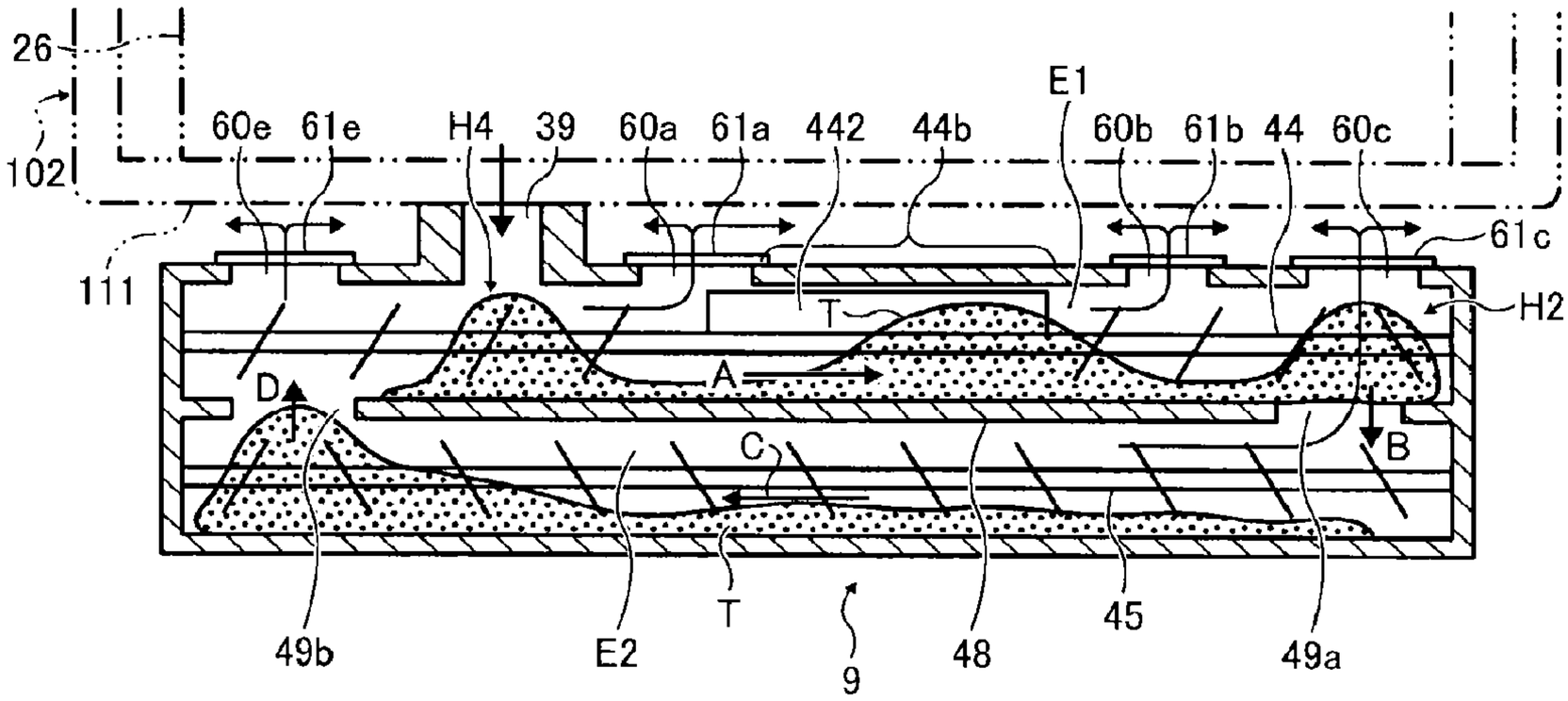
60a
61a
442
44b
H1
E1
44
60b
61b
60c
61c
H2
T
A
D
H3
C
B
49b
E2
T
9
48
45
49a

FIG. 13


26
102
111
60e
61e
H4
39
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61a
442
44b
E1
60b
61b
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60c
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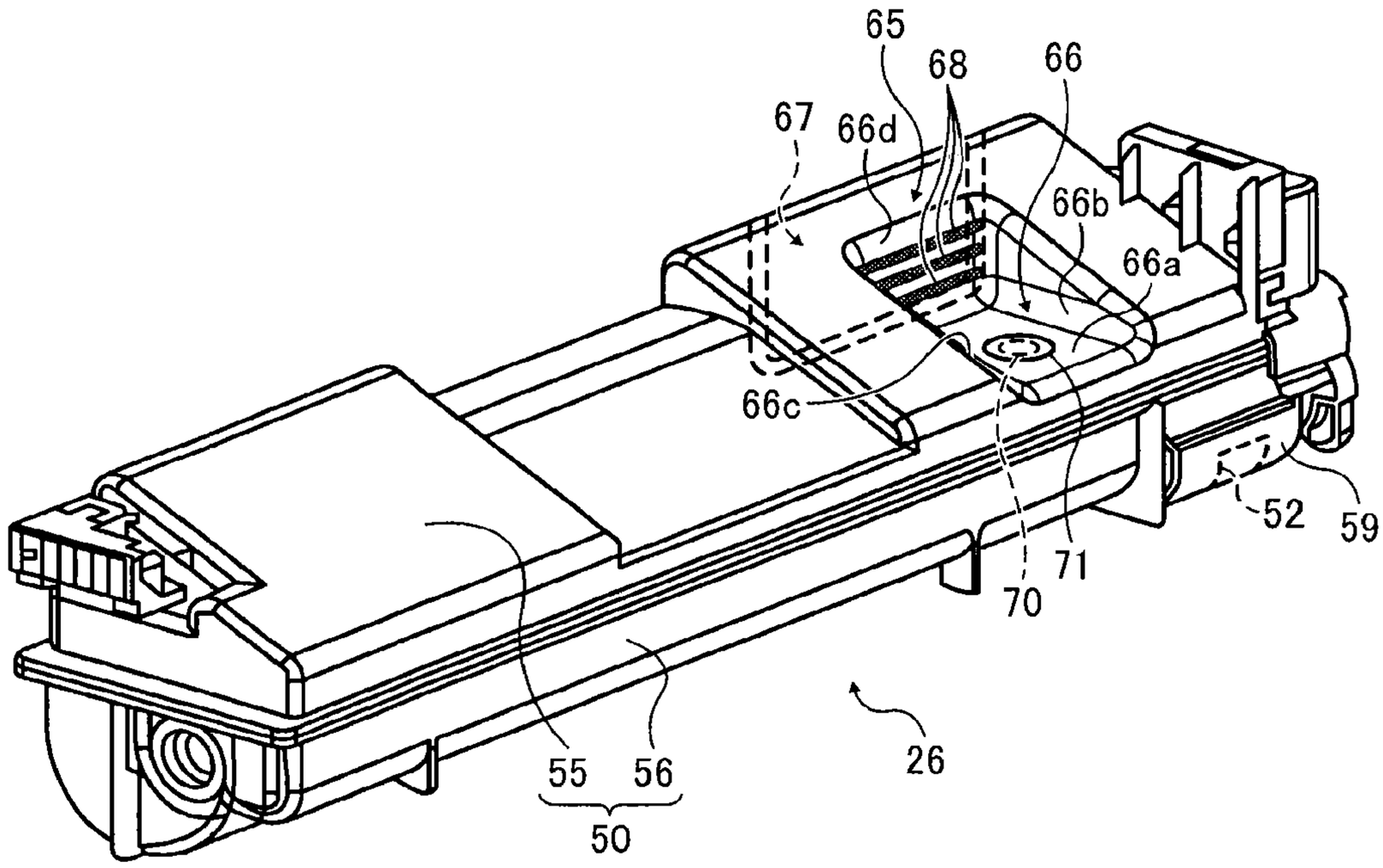
49b
E2
T
9
48
45
49a

FIG. 14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66d
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66c
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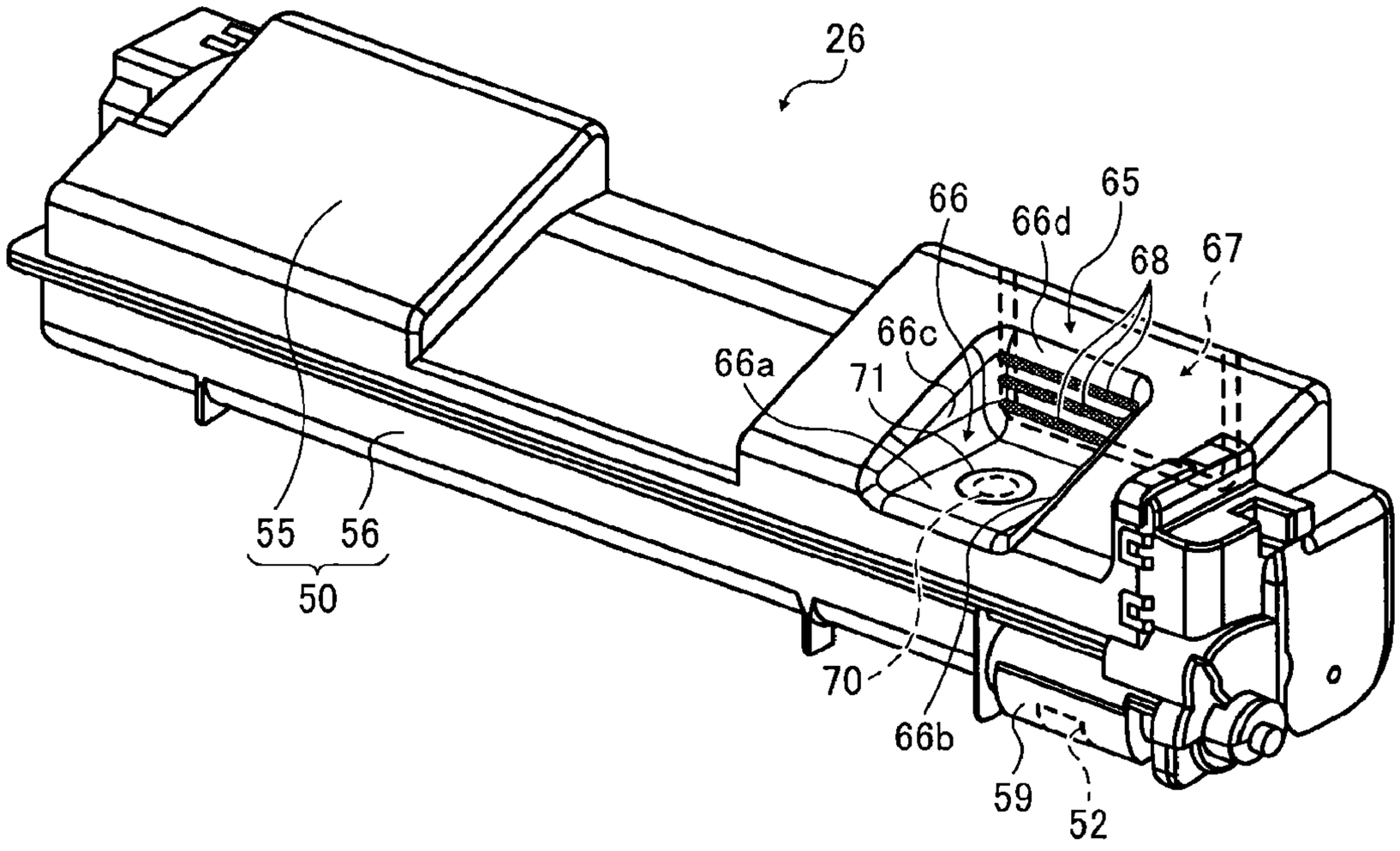
50
26

FIG. 15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66c
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56
50
70
66b
59
52

FIG. 16

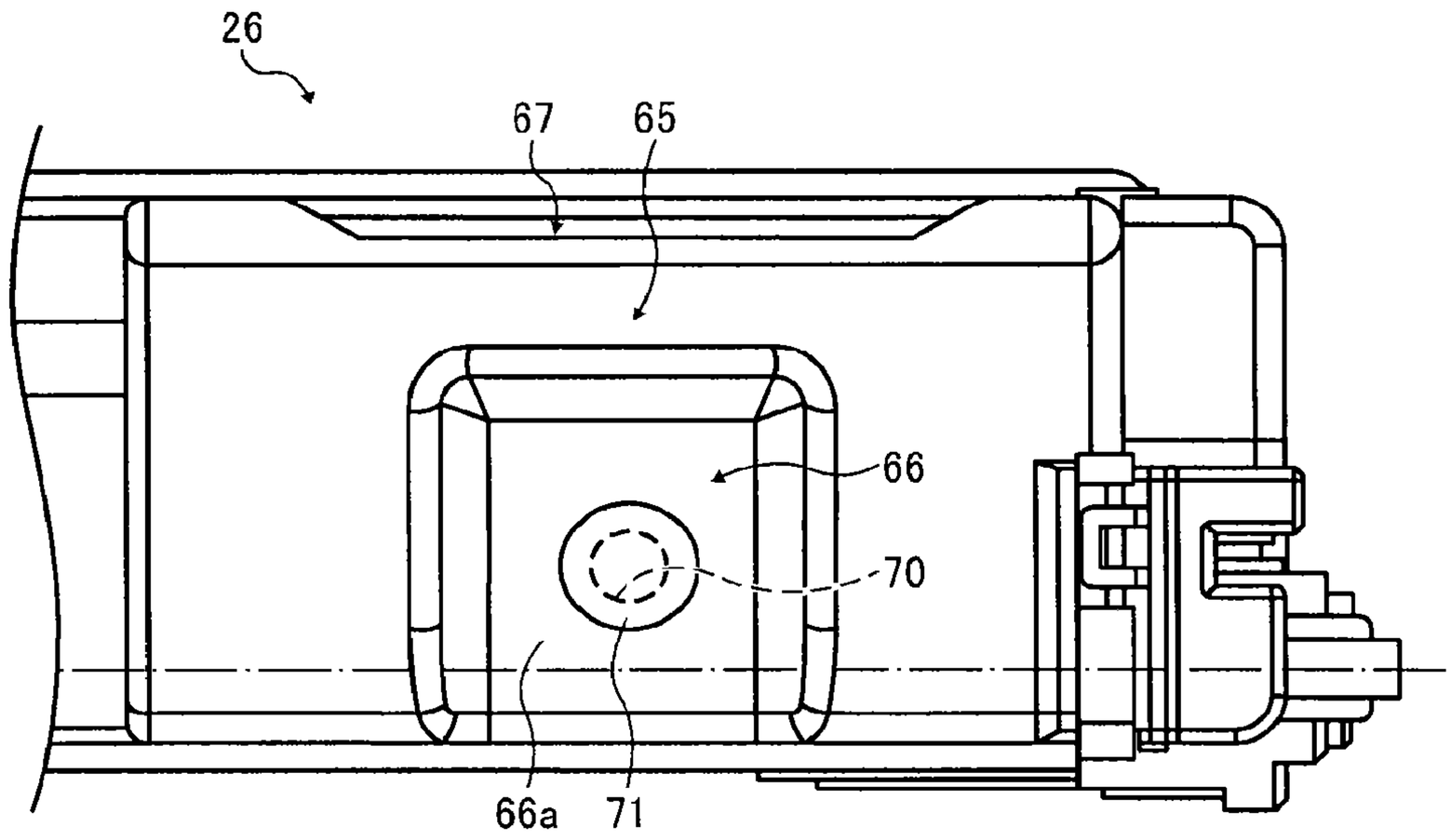


FIG. 17

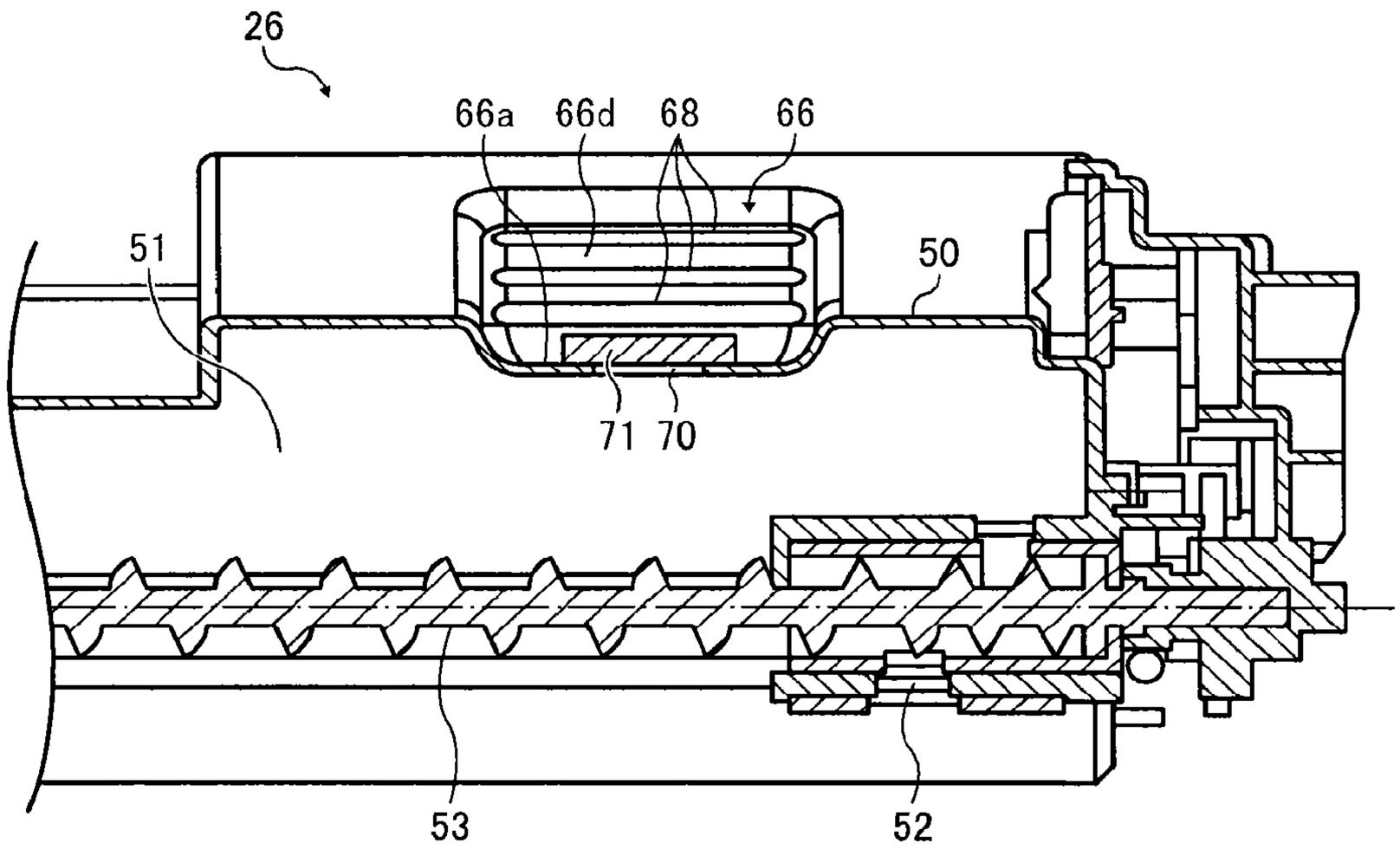


FIG. 18

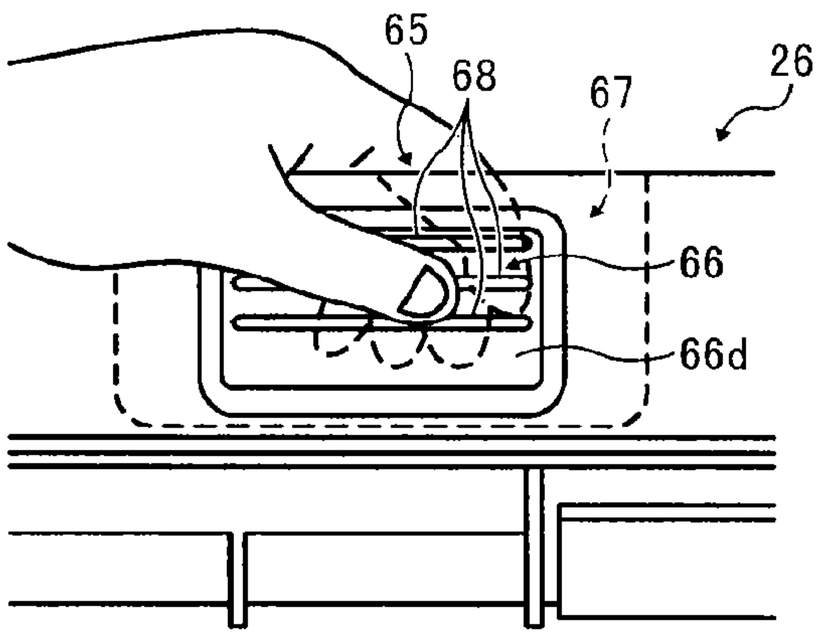


FIG. 19

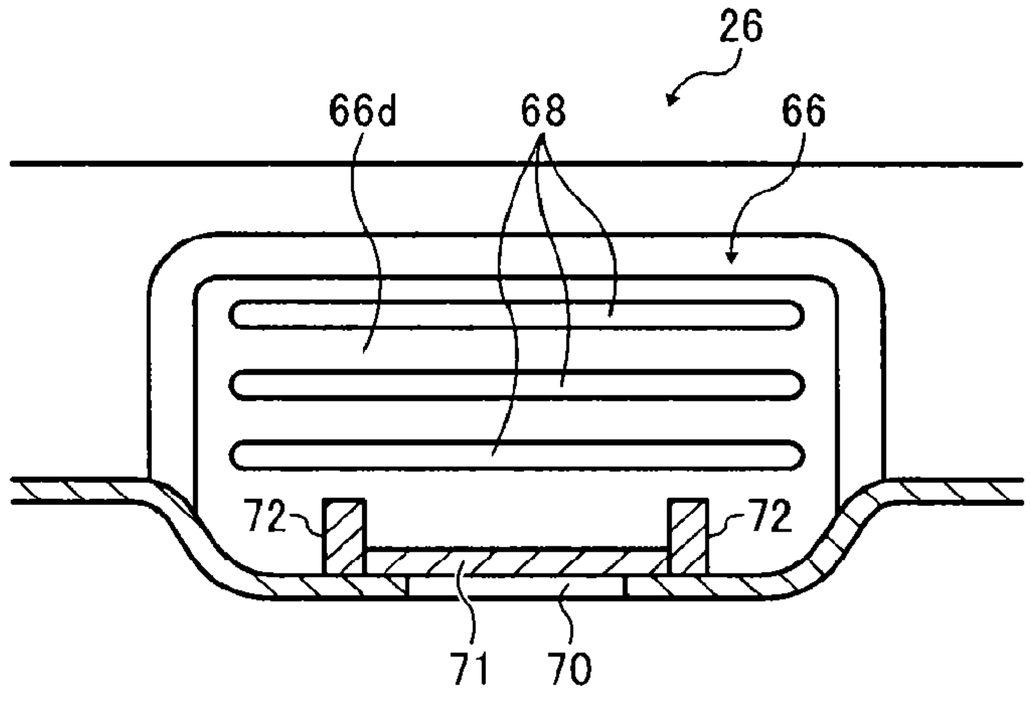
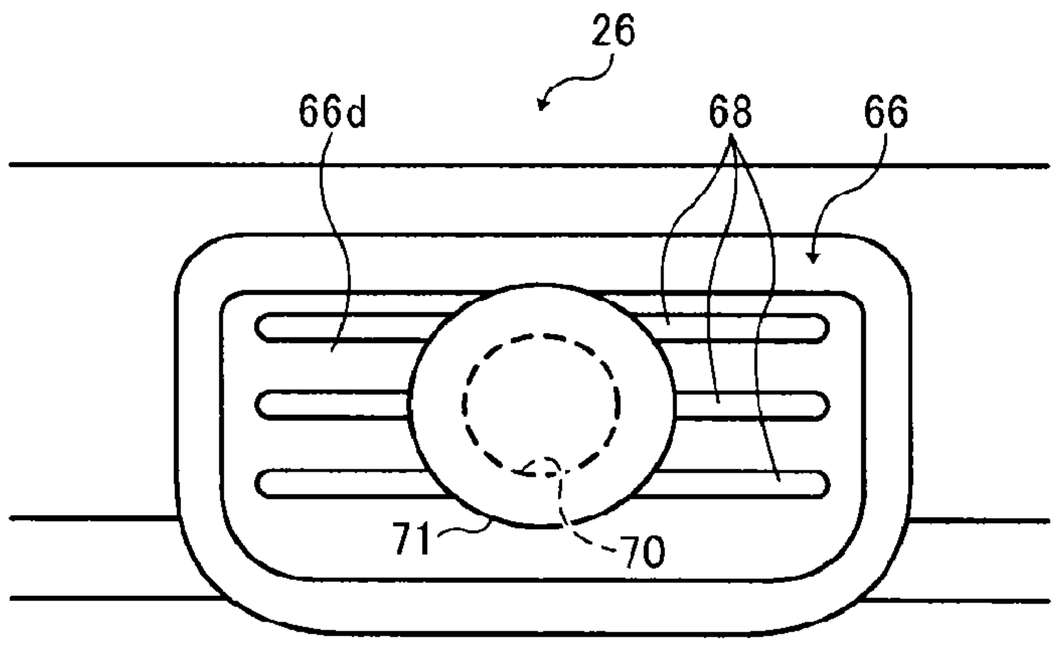


FIG. 20



POWDER CONTAINER, DEVELOPING DEVICE, PROCESS UNIT, AND IMAGE FORMING APPARATUS

CROSS-REFERENCE TO RELATED APPLICATIONS

This patent application is based on and claims priority pursuant to 35 U.S.C. §119(a) to Japanese Patent Application Nos. 2015-078445 and 2015-165977, filed on Apr. 7, 2015 and Aug. 25, 2015, respectively, in the Japan Patent Office, the entire disclosure of each of which is hereby incorporated by reference herein.

BACKGROUND

Technical Field

The present disclosure relates to a powder container, a developing device, a process unit, and an image forming apparatus.

Description of the Related Art

A developing device to be mounted on an electrophotographic image forming apparatus, such as copier and printer, is generally provided with a conveyer, such as a screw, to convey developer inside the developing device.

As an example, a developing device is known, which conveys developer within a circulation path that is divided into an upper compartment and a lower compartment by a partition. More specifically, the upper compartment, serving as a development chamber, and the lower compartment, serving as an agitation chamber, are in communication with each other through openings provided on respective ends of the partition. One of the openings serves as a drawing part where developer is drawn up and the other opening serves as a dropping part where developer is dropped down. Inside each of the development chamber and the agitation chamber, a screw is provided. As the screws rotate, developer in the development chamber is conveyed to the dropping part and dropped down to the agitation chamber, and developer in the agitation chamber is conveyed to the drawing part and drawn up to the development chamber.

SUMMARY

In accordance with some embodiments of the present invention, a powder container is provided. The powder container includes a powder storage and a conveyer. The powder storage stores a powder to be used for image formation and has a vent hole to pass air between an inside and an outside of the powder storage. The conveyer conveys the powder inside the powder storage. The vent hole is on an upper surface of the powder storage facing the conveyer.

In accordance with some embodiments of the present invention, a developing device is provided. The developing device includes a developer container to contain a developer, a developer bearer to bear the developer, and a developer supplier to supply the developer from the developer container to the developer bearer. The developer container includes the above powder container, and the developer includes the above powder to be used for image formation.

In accordance with some embodiments of the present invention, a process unit detachably mountable on an image forming apparatus is provided. The process unit includes a latent image bearer to bear a latent image and the above developing device to develop the latent image on the latent image bearer with the developer.

In accordance with some embodiments of the present invention, an image forming apparatus is provided. The image forming apparatus includes a latent image bearer to bear a latent image and a developing device to develop the latent image on the latent image bearer with a developer. The developing device includes a developer container to contain a developer, a developer bearer to bear the developer, and a developer supplier to supply the developer from the developer container to the developer bearer. The developer container includes the above powder container, and the developer includes the above powder to be used for image formation.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete appreciation of the disclosure and many of the attendant advantages thereof will be readily obtained as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. **1** is a schematic view of an image forming apparatus according to an embodiment of the present invention;

FIG. **2** is a schematic view of the image forming apparatus illustrated in FIG. **1** in a state in which a cover is opened;

FIG. **3** is a schematic view of the image forming apparatus illustrated in FIG. **1** in a state in which the cover is opened and a container holder is revolved upward;

FIG. **4** is a perspective view of the container holder in the image forming apparatus illustrated in FIG. **1**;

FIG. **5** is a cross-sectional view of a toner cartridge and a developing device according to an embodiment of the present invention;

FIG. **6** is a cross-sectional view of a related-art developing device;

FIG. **7** is a schematic cross-sectional view of the developing device illustrated in FIG. **5** taken along the axial direction of conveyance screws;

FIG. **8** is a perspective view of the developing device illustrated in FIG. **5**;

FIG. **9** is a perspective view of a developing device according to another embodiment of the present invention;

FIG. **10** is a perspective view of a developing device according to another embodiment of the present invention;

FIGS. **11**A and **11**B are cross-sectional side view and plan view, respectively, of a ventilation sheet attached to a development housing according to an embodiment of the present invention;

FIG. **12** a schematic cross-sectional view of a developing device according to an embodiment of the present invention;

FIG. **13** is a schematic cross-sectional view of a developing device according to another embodiment of the present invention;

FIG. **14** is a perspective view of a toner cartridge according to an embodiment of the present invention;

FIG. **15** is another perspective view of the toner cartridge illustrated in FIG. **14**;

FIG. **16** is a plan view of the toner cartridge illustrated in FIG. **14**;

FIG. **17** is a cross-sectional view of the toner cartridge illustrated in FIG. **14** taken along the axial direction of a conveyance screw;

FIG. **18** is an illustration of the toner cartridge illustrated in FIG. **14** when gripped by user;

FIG. **19** is a magnified cross-sectional view of a selected part of a toner cartridge according to another embodiment of the present invention; and

FIG. **20** is a magnified cross-sectional view of a selected part of a toner cartridge according to another embodiment of the present invention.

The accompanying drawings are intended to depict example embodiments of the present invention and should not be interpreted to limit the scope thereof. The accompanying drawings are not to be considered as drawn to scale unless explicitly noted.

DETAILED DESCRIPTION

Embodiments of the present invention are described in detail below with reference to accompanying drawings. In describing embodiments illustrated in the drawings, specific terminology is employed for the sake of clarity. However, the disclosure of this patent specification is not intended to be limited to the specific terminology so selected, and it is to be understood that each specific element includes all technical equivalents that operate in a similar manner and achieve a similar result.

For the sake of simplicity, the same reference number will be given to identical constituent elements such as parts and materials having the same functions and redundant descriptions thereof omitted unless otherwise stated.

In the known developing device having a circulation path divided into an upper compartment and a lower compartment, at portions where developer is moved in the direction intersecting with the axial direction of the screws, i.e., the dropping part and the drawing part, developer conveyance speed becomes slow, causing developer to easily accumulate in these portions. In a case in which the screw has a planar agitation blade in part, it is difficult in that part to generate a developer conveyance force to convey developer in the axial direction. Therefore, it is likely that developer becomes stagnant or accumulates in that part.

Accumulated developer prevents the air within the circulation path from being moved along with developer when the developer is conveyed within the circulation path, thus increasing the inner pressure of the circulation path. As the inner pressure increases, developer is pressurized to cause aggregation. Aggregated developer is hardly smoothly conveyed within the circulation path. In addition, aggregated developer possibly clogs the circulation path.

Defective conveyance of developer is induced by fluctuation of the inner pressure not only in developing device, but also in powder containers such as toner cartridge for storing toner. Further, recently, developing devices and powder containers have been improved in airtightness to more effectively prevent air leakage, downsized in accordance with downsizing of image forming apparatus, and developer conveyance path has become more complicated in its structure. Because of these factors, defective conveyance or clogging of developer is more likely to occur.

In accordance with some embodiments of the present invention, a powder container is provided which allows air to flow in or out through a vent hole when a powder is being conveyed therein. This powder container can suppress a fluctuation of the inner pressure and prevent defective conveyance of the powder.

FIG. **1** is a schematic view of an image forming apparatus according to an embodiment of the present invention. This image forming apparatus is a color printer (hereinafter simply "printer"). The image forming apparatus is not limited to the color printer and can be a monochrome printer, a copier, a facsimile machine, or a multifunction peripheral combining at least two functions of printing, copying, facsimile transmission, and scanning.

Referring to FIG. **1**, the printer includes an image forming unit **1**, a transfer unit **2**, a recording medium supply unit **3**, a fixing unit **4**, and a recording medium ejection unit **5**.

The image forming unit **1** includes four process units **6**Y, **6**M, **6**C, and **6**Bk serving as image forming units. The process units **6**Y, **6**M, **6**C, and **6**Bk have the same configuration except for containing different color toners, i.e., yellow (Y), magenta (M), cyan (C), and black (Bk) toners, respectively, corresponding to decomposed color components of full-color images.

Each of the process units **6**Y, **6**M, **6**C, and **6**Bk includes a photoconductor **7** serving as a latent image bearer, a charging roller **8** serving as a charger to charge the surface of the photoconductor **7**, a developing device **9** to develop the latent image on the photoconductor **7**, and a photoconductor cleaner **10** to clean the surface of the photoconductor **7**. Additionally, irradiators **11** are disposed facing the respective photoconductors **7**. The irradiators **11** serve as latent image forming devices to form latent images on the surfaces of the photoconductors **7**. In the present embodiment, the irradiators **11** contain a light emitting diode (LED) unit. Alternatively, the irradiators **11** may employ a laser beam scanner containing a laser diode.

The transfer unit **2** includes an intermediate transfer belt **12**, multiple primary transfer rollers **13**, a secondary transfer roller **14**, and a belt cleaner **17**. The intermediate transfer belt **12** is in the form of an endless belt, and a toner image (hereinafter simply "image") is transferred from the photoconductor **7** thereonto. Each primary transfer roller **13** primarily transfers the image from the photoconductor **7** onto the intermediate transfer belt **12**. The secondary transfer roller **14** secondarily transfers the image from the intermediate transfer belt **12** onto a recording medium. The belt cleaner **17** removes residual toner particles remaining on the outer peripheral surface of the intermediate transfer belt **12**.

The intermediate transfer belt **12** is stretched taut with a driving roller **15** and a driven roller **16**. The intermediate transfer belt **12** revolves as the driving roller **15** rotates. Each primary transfer roller **13** contacts the respective one of the photoconductors **7** with the intermediate transfer belt **12** therebetween. At each portion where the primary transfer roller **13** contacts the photoconductor **7** with the intermediate transfer belt **12** therebetween, a primary transfer nip is formed. At the primary transfer nip, the image is transferred from the photoconductor **7** onto the intermediate transfer belt **12**. The secondary transfer roller **14** contacts the driving roller **15** with the intermediate transfer belt **12** therebetween. At a portion where the secondary transfer roller **14** contacts the driving roller **15** with the intermediate transfer belt **12** therebetween, a secondary transfer nip is formed. In the secondary transfer nip, the image is transferred from the intermediate transfer belt **12** onto a recording medium.

The recording medium supply unit **3** includes a sheet tray **18**, a feed roller **19**, and a timing roller pair **20**. The sheet tray **18** stores a plurality of sheets P of paper serving as recording media. The feed roller **19** feeds the sheets P, one by one, from the sheet tray **18**. The timing roller pair **20** feeds the sheet P fed by the feed roller **19** to the secondary transfer nip at a predetermined timing. In addition to sheets of paper, the recording media may be sheets or films of overhead projector (OHP) transparency. Examples of the paper include plain paper, heavy paper, postcard, envelope, thin paper, coated paper (e.g., art paper), and tracing paper.

The fixing unit **4** includes a fixing device **21** to fix the image on the sheet P. The fixing device **21** includes a fixing roller **22** and a pressure roller **23**. The fixing roller **22** is heated by a heat source (e.g., heater). The pressure roller **23**

contacts the fixing roller **22** at a predetermined pressure to form a fixing nip therebetween.

The recording medium ejection unit **5** includes an ejection roller pair **24** and an ejection tray **25**. The ejection roller pair **24** ejects the sheet P fed from the fixing device **21** from the printer. The sheet P ejected by the ejection roller pair **24** is stacked on the ejection tray **25**.

The printer further includes multiple toner cartridges **26** each serving as a powder container for storing toner (developer) used for image formation. Each toner cartridge **26** stores toner having the same color as that contained in the corresponding developing device **9**. When the amount of toner stored in the developing device **9** falls below a predetermined amount, toner is supplied from the toner cartridge **26** thereto. The printer further includes a waste-toner container **27** serving as another powder container independent from the toner cartridges **26**. The waste-toner container **27** stores waste toner collected by the belt cleaner **17** and the photoconductor cleaners **10**.

Example operation of the printer is described below with reference to FIG. **1**.

When image formation is started, the photoconductor **7** is driven to rotate, and the charging roller **8** uniformly charges the surface of the photoconductor **7** to a predetermined polarity. The irradiator **11** emits laser light to the charged surface of the photoconductor **7** based on image information transmitted from a reading device or a computer to form a latent image (electrostatic latent image) thereon. More specifically, the latent images are formed on the surfaces of the photoconductors **7** based on respective single color information, namely, yellow, cyan, magenta, and black color information decomposed from full-color image information. The latent image formed on the photoconductor **7** is developed into a toner image (visible image) with toner supplied from the developing device **9**.

The toner images are sequentially transferred from the photoconductors **7** onto the intermediate transfer belt **12** that is revolving, and superimposed on one another on the intermediate transfer belt **12**. More specifically, when the toner image on the photoconductor **7** reaches the primary transfer nip, the toner image is transferred from the photoconductor **7** onto the intermediate transfer belt **12***a* by a transfer electric field formed by applying a predetermined voltage to the primary transfer roller **13**. Thus, a full-color composite toner image is formed on the surface of the intermediate transfer belt **12**. Residual toner particles remaining on the photoconductor **7** without being transferred onto the intermediate transfer belt **12** are removed by the photoconductor cleaner **10**.

On the other hand, when the image formation is started, the feed roller **19** starts rotating to feed the sheet P from the sheet tray **18**. Conveyance of the sheet P is once stopped by the timing roller pair **20**. The timing roller pair **20** restarts rotating at a predetermined timing to feed the sheet P to the secondary transfer nip in synchronization with an entry of the composite toner image on the intermediate transfer belt **12** into the secondary transfer nip.

At that time, a predetermined voltage is applied to the secondary transfer roller **14**, and thus a transfer electric field is formed in the secondary transfer nip. The composite toner image is transferred from the intermediate transfer belt **12** onto the sheet P at a time by the transfer electric field formed in the secondary transfer nip. Residual toner particles remaining on the intermediate transfer belt **12** without being transferred onto the sheet P are removed by the belt cleaner **17**.

The sheet P is then conveyed to the fixing device **21**. The fixing roller **22** and the pressure roller **23** heat and pressurize the toner image to fix the toner image on the sheet P. The ejection roller pair **24** ejects the sheet P from the printer onto the ejection tray **25**.

It is to be noted that, although the description above performs multicolor image formation, alternatively, the printer can form single-color images, bicolor images, or three-color images using one, two, or three of the four process units **6**Y, **6**M, **6**C, and **6**Bk.

Referring to FIG. **1**, the printer includes an apparatus body **100** and a cover **101** to open and close an upper part of the apparatus body **100**. The cover **101** is revolvable upward and downward about a revolving shaft **103** disposed in the apparatus body **100**. Below the cover **101**, a container holder **102** to detachably hold the four toner cartridges **26** is disposed. The container holder **102** is revolvable upward and downward about another revolving shaft **104** disposed in the apparatus body **100**.

FIG. **2** is a schematic view of the image forming apparatus illustrated in FIG. **1** with the cover **101** revolved upward. FIG. **3** is a schematic view of the image forming apparatus with both the cover **101** and the container holder **102** revolved upward.

When the cover **101** is revolved upward as illustrated in FIG. **2**, an upper part of the apparatus body **100** is opened. Thus, the toner cartridges **26** can be taken out from the container holder **102** upward through the opened part.

When the container holder **102** is revolved upward, as illustrated in FIG. **3**, from its default position at which the container holder **102** is horizontally disposed, the toner cartridges **26** along with the container holder **102** are retreated upward from the process units **6**Y, **6**M, **6**C, and **6**Bk to be in retreat positions. The irradiators **11**, disposed on the lower surface of the container holder **102**, are also retreated upward from the process units **6**Y, **6**M, **6**C, and **6**Bk as the container holder **102** is revolved. When the container holder **102** is revolved upward to be in a retreat position, the process units **6**Y, **6**M, **6**C, and **6**Bk can be taken out through the opened part of the apparatus body **100** without causing interference with the toner cartridges **26** or the irradiators **11**.

FIG. **4** is a perspective view of the container holder **102**.

Referring to FIG. **4**, the container holder **102** includes a bottom **111** having a substantially rectangular shape, a back wall **112** provided to one side of the bottom **111**, and a pair of side walls **113** and **114** respectively provided to two opposing sides of the bottom **111** intersecting with the back wall **112**. The toner cartridges **26** are mounted to between the pair of side walls **113** and **114** parallel to each other. In addition, a bearing **115** having a cylindrical shape, into which the revolving shaft **104** is inserted, is provided to the back wall **112**.

Descriptions are given below of the toner cartridge **26** and the developing device **9**.

In the descriptions below, "vertical direction" with respect to the toner cartridge **26** and the developing device **9** is defined when they are mounted to the apparatus body **100**. When it is described that "the toner cartridge **26** is mounted to the apparatus body **100**", it means that the toner cartridge **26** is in the default position at which the container holder **102** is horizontally disposed.

FIG. **5** is a schematic cross-sectional view of the toner cartridge **26** and the developing device **9**.

Referring to FIG. **5**, the toner cartridge **26** includes a container body **50** in which a developer storage **51** for storing toner (developer) is formed. The container body **50**

has a discharge opening **52** through which toner is discharged from the developer storage **51** outside. The container body **50** includes a conveyance screw **53** and an agitator **54**. The conveyance screw **53** conveys toner inside the developer storage **51** to the discharge opening **52**. The agitator **54** agitates toner inside the developer storage **51**.

The conveyance screw **53** includes a rotary shaft **530** and a spiral blade **531** winding around the outer circumference of the rotary shaft **530**. The agitator **54** includes a rotary shaft **540** parallel to the rotary shaft **530** of the conveyance screw **53** and a planar blade **541** provided to the rotary shaft **540**. The planar blade **541** is made of a flexible material, such as PET (polyethylene terephthalate) film. When a bottom face **501** of the developer storage **51** is curved into an arc in conformity with an orbit of rotation of the blade **541** as illustrated in FIG. **5**, the amount of toner which is not moved but remains inside the developer storage **51** can be reduced.

On the bottom **111** of the container holder **102** to which the toner cartridge **26** is mounted, a through hole **116** is formed. The through hole **116** connects the discharge opening **52** on a lower part of the toner cartridge **26** with a supply opening **39** on an upper part of the developing device **9**. More specifically, as illustrated in FIG. **5**, when the toner cartridge **26** is mounted to the container holder **102** and disposed above the developing device **9**, the discharge opening **52** of the toner cartridge **26** becomes communicated with the supply opening **39** of the developing device **9** through the through hole **116**. This configuration makes it possible to supply toner from the toner cartridge **26** to the developing device **9**.

The developing device **9** includes a development housing **40** serving as the powder container for storing toner (developer), a developing roller **41** for bearing toner (developer), a supply roller **42** for supplying toner (developer) to the developing roller **41**, a doctor blade **43** to regulate the amount of toner (developer) carried on the developing roller **41**, two conveyance screws **44** and **45** for conveying toner (developer), and two light guides **46** and **47**.

The space within the development housing **40**, serving as the powder storage, is divided by a partition **48** into a first compartment (upper compartment) E**1** and a second compartment (lower compartment) E**2**. The partition **48** has two communication openings **49***a* and **49***b*. The communication openings **49***a* and **49***b* are respectively formed at each end portion of the partition **48** in the direction perpendicular to the paper plane on which FIG. **5** is drawn. The first compartment E**1** and the second compartment E**2** are in communication with each other through the communication openings **49***a* and **49***b*.

In the first compartment E**1**, the two light guides **46** and **47** and the conveyance screw **44** are disposed. In the second compartment E**2**, the developing roller **41**, the supply roller **42**, the doctor blade **43**, and the conveyance screw **45** are disposed. The conveyance screw **44** includes a rotary shaft **440** and a spiral blade **441** winding around the outer circumference of the rotary shaft **440**. Similarly, the conveyance screw **45** includes a rotary shaft **450** and a spiral blade **451** winding around the outer circumference of the rotary shaft **450**. The conveyance screws **44** and **45** convey toner inside the first compartment E**1** and the second compartment E**2**, respectively, in opposite directions.

When toner conveyed by the conveyance screws **44** and **45** in opposite directions reaches downstream end portions of the first and second compartments E**1** and E**2**, respectively, relative to the direction of conveyance of toner (hereinafter "toner conveyance direction"), the toner is forwarded to the other compartment E**2** and E**1**, respectively, through the respective communication openings **49***a* and **49***b* formed at the either end portion of the partition **48**. Thus, toner is circulated between the first compartment E**1** and the second compartment E**2**. Since fresh toner supplied from the toner cartridge **26** and the toner inside the development housing **40** are mixed with each other by the circulation, the ratio of fresh toner in the toner inside the development housing **40** can become uniform, thus reducing color unevenness and background fouling in output images.

The developing roller **41** can include a metallic cored bar and a conductive rubber layer overlying the cored bar. Examples of the conductive rubber include, but are not limited to, conductive urethane rubber and silicone rubber. The developing roller **41** rotates counterclockwise in FIG. **5** and conveys the developer carried thereon to a position facing the doctor blade **43** and a position facing the photoconductor **7**.

The supply roller **42** can be a sponge roller. Preferred sponge roller includes a metallic cored bar and a semiconductive foamed polyurethane adhering to the cored bar. Foamed polyurethane can be made semiconductive by mixing carbon therein. The supply roller **42** is disposed in contact with the developing roller **41** to form a nip therebetween. The size of the nip is typically about 1 to 3 mm.

The doctor blade **43** can be composed of a plate of a metal, such as stainless steel (SUS), having a thickness of about 0.1 mm. One end of the doctor blade **43** is in contact with a surface of the developing roller **41**, forming a regulation nip therebetween. The doctor blade **43** controls the amount of toner carried on the developing roller **41** for the purpose of stabilizing developing property and improving image quality. For example, some marketed products of the image forming apparatus are strictly controlled so that the doctor blade **43** contacts the developing roller **41** at a pressure of about 20 to 60 N/m and the regulation nip is positioned 0.5±0.5 mm away from the end of the doctor blade **43**. These parameters can be determined in accordance with properties of developer (toner), the developing roller, and the supply roller.

Development operation of the above-described developing device **9** is described below with reference to FIG. **5**.

When the developing roller **41** and the supply roller **42** start rotating in response to a start command, the supply roller **42** supplies toner to the surface of the developing roller **41**. The supply roller **42** rotates so as to face in the direction of rotation of the developing roller **41** (i.e., counterclockwise in FIG. **5**), thus efficiently supplying the toner in the development housing **40** to the outer layer of the developing roller **41**. Additionally, in the present embodiment, the rotational frequency ratio between the developing roller **41** and the supply roller **42** is set to 1 so that toner can be supplied reliably.

While toner carried on the developing roller **41** passes through the nip between the developing roller **41** and the doctor blade **43**, the amount of toner is adjusted. Simultaneously, toner is charged through friction. When toner on the developing roller **41** reaches the position facing the photoconductor **7** (i.e., a development range), the toner electrostatically moves to the electrostatic latent image formed on the photoconductor **7**, thus developing it into a toner image.

Next, supply of toner to the developing device **9** is described in further detail below.

When the amount of toner inside the development housing **40** falls below a reference amount, toner is supplied to the developing device **9**. Whether or not the amount of toner is smaller than the reference amount can be determined

based on whether light is transmittable between the ends of the two light guides **46** and **47** disposed in the first compartment E**1**. When the amount of toner in the development housing **40** is equal to or greater than the reference amount, it means toner stands between the ends of the light guides **46** and **47** to prevent light from transmitting from one of the light guides to the other. By contrast, when the amount of toner is smaller than the reference amount, it means no toner stands between the ends of the light guides **46** and **47**, allowing light to transmit from one of the light guides to the other. In response to detection of transmission of light, a toner supply timing is obtained.

When it is determined that it is the toner supply timing, the conveyance screw **53** inside the toner cartridge **26** starts rotating and conveys toner to the discharge opening **52**. The conveyed toner is discharged from the discharge opening **52** and supplied to the development housing **40** via the through hole **116** and the supply opening **39**. More specifically, as the agitator **54** rotates, toner inside the toner cartridge **26** is agitated and conveyed toward the conveyance screw **53**. When the amount of toner inside the development housing **40** exceeds the reference amount, the conveyance screw **53** and the agitator **54** stop rotating. Thus, toner supply is completed.

A related-art developing device is described below with reference to FIG. **6**.

FIG. **6** is a cross-sectional view of a related-art developing device **9**X taken along the axial direction of conveyance screws **44** and **45**. Hereinafter, for the sake of simplicity, the same reference number will be given to identical constituent elements such as parts and materials having the same functions as those of the above-described developing device **9** according to an embodiment of the present invention and redundant descriptions thereof omitted unless otherwise stated.

Referring to FIG. **6**, in the related-art developing device **9**X, the inner space of the development housing **40** is divided by the partition **48** into the first compartment (upper compartment) E**1** and the second compartment (lower compartment) E**2**, in a similar way to the above-described developing device **9**. The first compartment E**1** and the second compartment E**2** are horizontally extended and communicated with each other in the vertical direction through the communication openings **49***a* and **49***b* provided to respective ends of the partition **48**.

The conveyance screws **44** and **45** are respectively disposed in the first compartment E**1** and the second compartment E**2**. The conveyance screws **44** and **45** horizontally convey toner T in opposite directions indicated by arrows A and C, respectively, in FIG. **6**. As toner T is supplied from the supply opening **39** formed on an upstream side of the first compartment E**1** relative to the toner conveyance direction, the conveyance screw **44** disposed in the first compartment E**1** conveys the toner T in the direction indicated by arrow A. The toner T then falls down in the direction indicated by arrow B through the communication opening **49***a* formed on a downstream side of the first compartment E**1** relative to the toner conveyance direction, being supplied to the second compartment E**2**. The toner T supplied to the second compartment E**2** is conveyed in the direction indicated by arrow C by the conveyance screw **45** disposed in the second compartment E**2**. The toner T is then pushed up in the direction indicated by arrow D through the communication opening **49***b* formed on a downstream side of the second compartment E**2** relative to the toner conveyance direction, being returned to the first compartment E**1**. Thus, toner T is circulated between the first compartment E**1** and the second compartment E**2** while being mixed.

Referring to FIG. **6**, the conveyance screws **44** and **45** have reverse winding parts **44***c* and **45***c*, respectively, in each of which the direction of winding of spiral blade is reversed, on their downstream ends relative to the toner conveyance direction. In the reverse winding parts **44***c* and **45***c*, toner T is conveyed in the direction opposite to the toner conveyance direction in upstream sides. Thus, particles of toner T collide with each other in these parts. Collision of toner particles generates a conveyance force which conveys toner T in the direction intersecting with the axial direction of the conveyance screws **44** and **45**. The conveyance force allows toner T to more easily fall down or to be pushed up.

Additionally, in the related-art developing device **9**X, the conveyance screw **44** disposed in the first compartment E**1** has a part in which the spiral blade **441** is omitted. Instead, the conveyance screw **44** has an agitation part **44***b* in which a planar blade **442** is provided in the axial direction. In the agitation part **44***b*, as the planar blade **442** rotates as the conveyance screw **44** rotates, toner T is moved mainly in the peripheral direction, thereby being agitated. Namely, the conveyance screw **44** disposed in the first compartment E**1** has a conveyance part **44***a* and the agitation part **44***b*. In the conveyance part **44***a*, the spiral blade **441** generates a conveyance force to convey toner T in the axial direction. In the agitation part **44***b*, the planar blade **442** generates an agitation force to move toner T in the peripheral direction.

Referring to FIG. **6**, the agitation part **44***b* is disposed around the middle part of the conveyance screw **44** in the axial direction. As toner T is supplied from the supply opening **39**, the upstream conveyance part **44***a* conveys the toner T downstream to the agitation part **44***b*. After the toner T is agitated in the agitation part **44***b*, the downstream conveyance part **44***a* further conveys the toner T downstream to the communication opening **49***a*. In the example illustrated in FIG. **6**, the conveyance screw **45** disposed in the second compartment E**2** has no agitation part, but may include an agitation part in which a planar blade is disposed.

As described above, in the related-art developing device **9**X, toner T is circulated between the first compartment E**1** and the second compartment E**2**. However, there are some portions in the first compartment E**1** and the second compartment E**2** in which toner T easily accumulates. Specifically, such portions include a portion H**1** in the vicinity of the agitation part **44***b*, a portion H**2** in the vicinity of the communication opening **49***a* through which toner T falls down, and a portion H**3** in the vicinity of the communication opening **49***b* through which toner T is pushed up. At the agitation part **44***b*, it is difficult to generate a conveyance force which conveys toner in the axial direction since no spiral blade **441** is provided to the conveyance screw **44**. At the communication openings **49***a* and **49***b*, toner conveyance speed becomes slow since toner is moved in the direction intersecting with the axial direction of the conveyance screws **44** and **45**. Therefore, while being continuously conveyed from upstream sides, toner T easily accumulates in such portions. As toner T accumulates in such portions to some extent, the accumulated toner T prevents the air moved from upstream sides along with toner T from flowing downstream, thereby increasing the inner pressure at upstream sides of the toner-accumulated portions. As a result, toner T may be pressurized by the increased inner pressure to aggregate and prevented from being smoothly conveyed.

To prevent such defective conveyance of toner, the developing device **9** according to an embodiment of the present invention has the following configuration.

FIG. **7** is a schematic cross-sectional view of the developing device **9** taken along the axial direction of the conveyance screws **44** and **45**. FIG. **8** is a perspective view of the developing device **9**.

Referring to FIG. **7**, the developing device **9** has three vent holes **60***a*, **60***b*, and **60***c* to pass air inside and outside the development housing **40** and ventilation sheets **61***a*, **61***b*, and **61***c* to cover the respective vent holes **60***a*, **60***b*, and **60***c*. The developing device **9** has a similar configuration to the related-art developing device **9**X except for having the vent holes **60***a*, **60***b*, and **60***c* and the ventilation sheets **61***a*, **61***b*, and **61***c*. Hereinafter, for the sake of simplicity, the vent hole **60***a* closest to the supply opening **39**, the vent hole **60***b* second closest to the supply opening **39**, and the vent hole **60***c* farthest from the supply opening **39** are respectively referred to as first, second, and third vent holes.

The vent holes **60***a*, **60***b*, and **60***c* are formed upstream from the portions in which toner easily accumulates, relative to the toner conveyance direction, for effectively suppressing an increase of the inner pressure within the development housing **40** (i.e., the first compartment E**1** and the second compartment E**2**) in the developing device **9**.

More specifically, the first vent hole **60***a* is provided downstream from the supply opening **39** and upstream from the agitation part **44***b* relative to the toner conveyance direction. The second vent hole **60***b* is provided downstream from the agitation part **44***b* and upstream from the communication opening **49***a*, through which toner falls down, relative to the toner conveyance direction. The third vent hole **60***c* is provided downstream from the second vent hole **60***b* and upstream from the communication opening **49***b*, through which toner is pushed up, relative to the toner conveyance direction. Here, the toner conveyance direction is defined as a direction of conveyance of toner supplied from supply opening **39**. Hereinafter, the communication opening **49***a* through which toner falls down may be referred to as "fall port **49***a*", and the communication opening **49***b* through which toner is pushed up may be referred to as "push-up port **49***b*".

The vent holes **60***a*, **60***b*, and **60***c* and the ventilation sheets **61***a*, **61***b*, and **61***c* are provided on the upper surface of the development housing **40** so as not to be clogged with toner. More specifically, the vent holes **60***a*, **60***b*, and **60***c* are provided on the upper surface of the development housing **40** that faces the conveyance screw **44** in the first (upper) compartment E**1**. Among the three vent holes **60***a*, **60***b*, and **60***c*, the third vent hole **60***c* is provided above the fall port **49***a*. In particular, at least a part of the third vent hole **60***c* is overlapped with (or facing) the fall port **49***a* in the vertical direction, as is indicated by a range X in FIG. **7**.

Referring to FIG. **8**, in the present embodiment, the first vent hole **60***a* and the third vent hole **60***c* each have a rectangular shape longer in the toner conveyance direction (or in the longitudinal direction of the developing device **9**), and the second vent hole **60***b* has a square shape. More specifically, the vent holes **60***a*, **60***b*, and **60***c* have first lengths L**1***a*, L**1***b*, and L**1***c*, respectively, in the toner conveyance direction and second lengths L**2***a*, L**2***b*, and L**2***c*, respectively, in the direction perpendicular to the toner conveyance direction, and the first lengths are equal to or longer than the corresponding second length, i.e., L**1***a*>L**2***a*, L**1***b*=L**2**B, and L**1***c*>L**2***c* are satisfied. Owing to this configuration, even when a large amount of toner accumulates downstream, the vent holes **60***a*, **60***b*, and **60***c* are prevented from being clogged with the accumulated toner and maintain ventilation property. In particular, the first vent hole **60***a* and the third vent hole **60***c*, having the respective first lengths L**1***a* and L**1***c* in the toner conveyance direction longer than the respective second lengths L**2***a* and L**2***c* in the direction perpendicular to the toner conveyance direction (i.e., L**1***a*>L**2***a*, L**1***c*>L**2***c*), are more effectively prevented from being clogged with the accumulated toner.

When the sizes of the vent holes **60***a*, **60***b*, and **60***c* are too large, user is more likely to touch the ventilation sheets **61***a*, **61***b*, and **61***c* when detaching or attaching the process units from/to the image forming apparatus, possibly damaging the ventilation sheets **61***a*, **61***b*, and **61***c*. In view of this situation, the sizes of the vent holes **60***a*, **60***b*, and **60***c* are preferably as small as possible. In the present embodiment, the second vent hole **60***b* is shorter than the adjacent third vent hole **60***c* in the toner conveyance direction, i.e., L**1***b*<L**1***c*. This configuration prevents excessive enlargement of the vent holes **60***b* and **60***c*. By contrast, the second vent hole **60***b* is longer than the third vent hole **60***c* in the direction perpendicular to the toner conveyance direction, i.e., L**2***b*>L**2***c*. This configuration secures the ventilation quantity of the second vent hole **60***b*.

The shapes and sizes of the vent holes **60***a*, **60***b*, and **60***c* are determined in view of securement of ventilation property and prevention of damage caused by user, as described above, but are not limited to particular shapes and sizes. For example, it is possible that the second vent hole **60***b* is formed into a rectangular shape longer in the toner conveyance direction and the third vent hole **60***c* is formed into a square shape, as illustrated in FIG. **9**. Alternatively, it is also possible that the second vent hole **60***b* and the third vent hole **60***c* are integrally combined into a single vent hole **60***d* that is covered with a single ventilation sheet **61***d*, as illustrated in FIG. **10**. It is also possible that each of the vent holes **60***a*, **60***b*, and **60***c* has a shape other than a rectangular or square shape, such as a circular shape and a shape of an ellipse.

The ventilation sheets **61***a*, **61***b*, and **61***c* may be composed of porous films made of a resin. The ventilation sheets **61***a*, **61***b*, and **61***c* allow air but do not allow toner to pass through. The ventilation sheets **61***a*, **61***b*, and **61***c* are preferably composed of oil-repellent sheets to which toner is less likely to adhere, to prevent deterioration of ventilation property.

An attachment structure of the ventilation sheet to the development housing **40** is illustrated in FIGS. **11**A and **11**B.

FIGS. **11**A and **11**B are cross-sectional side view and plan view, respectively, of the ventilation sheet **61***a* attached to the development housing **40**. Since the ventilation sheets **61***a*, **61***b*, and **61***c* have the same configuration, only the ventilation sheet **61***a* is illustrated and the ventilation sheets **61***b* and **61***c* are omitted in FIGS. **11**A and **11**B.

Referring to FIG. **11**A, the ventilation sheet **61***a* is attached to the outer surface of the development housing **40** via a double-sided adhesive tape **62**. The double-sided adhesive tape **62** can be replaced with another adhesive member, such adhesive and glue.

In FIG. **11**B, a shaded area represents an area to which the double-sided adhesive tape **62** is attached. The ventilation sheet **61***a* is greater than the vent hole **60***a* in both longitudinal and transverse directions. The double-sided adhesive tape **62** is attached to the whole circumferential edge of the ventilation sheet **61***a*. The double-sided adhesive tape **62** is not overlapped with the vent hole **60***a* so as not to degrade ventilation property of the vent hole **60***a*. Namely, the double-sided adhesive tape **62** is attached to the ventilation sheet **61***a* in such a manner that an air-permeable area of the

ventilation sheet **61***a* (i.e., an area to which the double-sided adhesive tape **62** is not attached) becomes greater than the aperture of the vent hole **60***a*, i.e., F**1**≥G**1** and F**2**≥G**2** are satisfied.

Function effects of the vent holes **60***a*, **60***b*, and **60***c* are described below with reference to FIG. **12**.

When toner T is circulated within the developing device **9**, toner T accumulates in large amounts in the portion H**1** in the vicinity of the agitation part **44***b*, the portion H**2** in the vicinity of the communication opening **49***a* through which toner T falls down, and the portion H**3** in the vicinity of the communication opening **49***b* through which toner T is pushed up, similar to the case in which toner T is circulated within the related-art developing device **9**X illustrated in FIG. **6**. The developing device **9** according to an embodiment of the present invention is different from the related-art developing device **9**X in that the vent holes **60***a*, **60***b*, and **60***c* are provided upstream from the portions (hereinafter "accumulation portions") H**1**, H**2**, and H**3** in which toner T easily accumulates. Owing to this configuration, the air moved along with toner as the toner is conveyed within the conveyance path is discharged outside through the vent holes **60***a*, **60***b*, and **60***c*.

More specifically, the air on upstream sides from the accumulation portion H**1** in the vicinity of the agitation part **44***b* is discharged through the first vent hole **60***a*. The air on upstream sides from the accumulation portion H**2** in the vicinity of the fall port **49***a* is discharged through the second vent hole **60***b*. The air on upstream sides from the accumulation portion H**3** in the vicinity of the push-up port **49***b* is discharged through the third vent hole **60***c*. Although it looks as if the fall port **49***a* was clogged with the accumulated toner T in FIG. **12**, the fall port **49***a* almost never becomes clogged with toner T in actual. The air in the second compartment E**2** can be discharged from the third vent hole **60***c* through the fall port **49***a*. Since the third vent hole **60***c* is overlapped with the fall port **49***a* in the present embodiment, the air in the second compartment E**2** can be more easily discharged from the third vent hole **60***c* through the fall port **49***a*.

As illustrated in FIG. **12**, the container holder **102** holding the toner cartridge **26** (shown by two-dot chain lines) is disposed above the developing device **9** while forming a gap between the bottom **111** of the container holder **102** and the upper surface of the developing device **9**. Owing to the presence of the gap, the vent holes **60***a*, **60***b*, and **60***c* are never covered with the bottom **111** of the container holder **102** although the container holder **102** is disposed above the developing device **9**. Thus, the air discharged from the vent holes **60***a*, **60***b*, and **60***c* can flow out through the gap.

The developing device **9** according to an embodiment of the present invention is capable of suppressing an increase of the inner pressure of the conveyance path (i.e., the first compartment E**1** and the second compartment E**2**) since the air moved along with toner can be discharged outside through the vent holes **60***a*, **60***b*, and **60***c*. Thus, in the developing device **9**, toner is prevented from aggregating, toner fluidity is secured, and smooth conveyance of toner can be performed for an extended period of time.

FIG. **13** is a schematic cross-sectional view of the developing device **9** according to another embodiment of the present invention.

The developing device **9** illustrated in FIG. **13** is different from that illustrated in FIG. **12** in that the position of the supply opening **39** is changed. In particular, the position of the supply opening **39** illustrated in FIG. **13** is more downstream than that illustrated in FIG. **12** relative to the toner conveyance direction. Additionally, in the developing device illustrated in FIG. **13**, a fourth vent hole **60***e* and a ventilation sheet **61***e* covering the vent hole **60***e* are further provided upstream from the supply opening **39** relative to the toner conveyance direction.

Referring to FIG. **13**, toner T supplied from the supply opening **39** may easily accumulates on a position immediately below the supply opening **39**. This position is hereinafter referred to as "accumulation portion H**4**". Since the fourth vent hole **60***e* is provided upstream from the accumulation portion H**4** in which toner T easily accumulates, the air moved along with toner is discharged outside through the fourth vent hole **60***e*. Thus, an increase of the inner pressure of the space upstream from the accumulation portion H**4** in the vicinity of the supply opening **39** is suppressed, and toner is prevented from aggregating.

According to the present embodiment, since at least a part of the fourth vent hole **60***e* is disposed above the push-up port **49***b*, as toner T is pushed up through the push-up port **49***b*, the air is moved upward along with the toner T and discharged outside through the fourth vent hole **60***e*. Owing to this configuration, it becomes much easier to push up toner T, improving toner conveyance property.

It is to be noted that, other than the differences described above, configuration and operation of elements of the present embodiment are similar to those of the above-described embodiment, attaining similar effects. Thus, descriptions thereof are omitted.

In the above-described embodiments, horizontally-extended conveyance paths (i.e., the first compartment E**1** and second compartment E**2**) are arranged in parallel in the vertical direction. According to another embodiment, the horizontally-extended conveyance paths may be arranged in parallel in a direction intersecting with the extension direction of the conveyance paths. Even in such an embodiment, at a portion where toner is conveyed from one conveyance path to another conveyance path, toner is moved in the direction intersecting with the axial direction of the conveyance screws, and toner conveyance speed becomes slow and toner easily accumulates. When a vent hole is provided to the upper surface of the conveyance path that faces the conveying screw, an increase of the inner pressure is suppressed, preventing aggregation and defective conveyance of toner.

In the above-described embodiments, the agitation part having a planar blade is provided for the purpose of agitating toner. According to another embodiment, the planar blade is provided for another purpose. For example, the planar blade can be provided for the purpose of cleaning light-output or light-input surfaces of the light guides that detect a toner amount. In this case, the planar blade may be disposed in contact with the light-output or light-input surfaces. Even in such an embodiment, at a portion where the planar blade is provided to the conveyance screw (i.e., cleaning part), it is difficult to generate a toner conveyance force to convey toner in the axial direction and toner easily accumulates. When a vent hole is provided, an increase of the inner pressure is suppressed and defective conveyance of toner is prevented.

The vent holes and ventilations sheets having the above-described configurations (as illustrated in FIGS. **7** to **13**) can be applied not only to developing devices (development housings) but also to other powder containers, such as toner cartridge and waste-toner container.

Descriptions are given below of a toner cartridge having a vent hole and a ventilation sheet.

It is to be noted that, other than differences described below, configuration and operation of elements of the following embodiments are similar to those of the toner cartridge according to the above-described embodiment, attaining similar effects. Thus, descriptions thereof are omitted.

FIGS. **14** and **15** are perspective views of the toner cartridge **26**. FIG. **16** is a plan view of the toner cartridge **26**. FIG. **17** is a cross-sectional view of the toner cartridge **26** taken along the axial direction of the conveyance screw **53**. In each of FIGS. **16** and **17**, a dot-and-dash line represents the rotation axis of the conveyance screw **53**.

Referring to FIGS. **14** and **15**, the toner cartridge **26** includes the container body **50** longitudinally extended. The container body **50** includes an upper case **55** and a lower case **56** bonded to each other. Referring to FIG. **17**, the conveyance screw **53** is longitudinally extended inside the developer storage **51** inside the container body **50**. The conveyance screw **53** conveys toner inside the developer storage **51** to the discharge opening **52** provided to one end part (right end part in FIGS. **14** and **15**) of the container body **50**. The container body **50** further includes a shutter **59** to open and close the discharge opening **52**.

To the end part of the container body **50** having the discharge opening **52**, a vent hole **70** to pass air inside and outside the toner cartridge **26** and a ventilation sheet **71** for covering the vent hole **70** are provided. Similar to the ventilation sheets **61***a*, **61***b*, and **61***c* provided to the above-described developing device **9**, the ventilation sheet **71** may be composed of a porous film made of a resin. The ventilation sheet **71** allows air but does not allow toner to pass through. The ventilation sheet **71** is preferably composed of an oil-repellent sheet to which toner is less likely to adhere. In the present embodiment, a single vent hole **70** and a single ventilation sheet **71** are provided. According to another embodiment, multiple vent holes and multiple ventilation sheets may be provided.

As illustrated in FIG. **17**, the vent hole **70** and the ventilation sheet **71** are provided on the upper surface of the container body **50** that faces the conveyance screw **53** in the developer storage **51**. In particular, the vent hole **70** and the ventilation sheet **71** are provided to an upper surface recess **66** formed on the upper surface of the upper case **55**. The upper surface recess **66** and a back surface recess **67** that is formed on the back surface side of the upper case **55**, as illustrated in FIGS. **14** to **16**, cooperatively serves as a gripper **65** of the toner cartridge **26** to be gripped by user.

More specifically, the upper surface recess **66** is formed with a bottom surface **66***a*, left and right side surfaces **66***b* and **66***c*, and a back side surface **66***d*. The bottom surface **66***a* is disposed horizontally when the toner cartridge **26** is mounted to the apparatus body **100**. The left and right side surfaces **66***b* and **66***c* are disposed upright at respective left and right sides of the bottom surface **66***a*. The back side surface **66***d* is disposed upright at the back surface side of the bottom surface **66***a*. In particular, the vent hole **70** and the ventilation sheet **71** are provided to the bottom surface **66***a*. The back side surface **66***d* particularly functions as the gripper **65**.

FIG. **18** is an illustration of the toner cartridge **26** gripped by user.

As illustrated in FIG. **18**, user can grip the toner cartridge **26** by pressing a thumb against the back side surface **66***d* of the upper surface recess **66** while pressing fingers other than the thumb against the back surface recess **67**. In the present embodiment, multiple ribs **68** are further provided to the back side surface **66***d* to prevent fingers from slipping.

When toner inside a toner cartridge is conveyed by a conveyance screw to a discharge opening of the toner cartridge and supplied to a developing device, the air in the toner cartridge is also pushed out from the toner cartridge along with the toner. As a result, the inner pressure of the toner cartridge is decreased. In a case in which the toner cartridge has no vent hole, as the inner pressure is decreased, air will flow into the toner cartridge through the discharge opening. The incoming air will cause reverse flow and defective conveyance (supply) of the toner.

By contrast, according to an embodiment of the present invention, the toner cartridge **26** has the vent hole **70**. Even when the air in the toner cartridge **26** is discharged outside through the discharge opening **52** as the toner is conveyed (supplied) to the developing device **9**, it is possible to introduce air inside the toner cartridge **26** through the vent hole **70**. Thus, a decrease of the inner pressure of the toner cartridge **26** can be suppressed. In the above-described embodiment, the vent hole **70** is provided on a side closer to the discharge opening **52**. Therefore, a decrease of the inner pressure can be effectively suppressed at around the discharge opening **52**. According to the above-described embodiment, the toner cartridge **26** can effectively suppresses a decrease of the inner pressure caused when toner is conveyed. Toner is prevented from reversely flowing out through the discharge opening **52** and is reliably conveyed (supplied).

In the above-described embodiment, the vent hole **70** and the ventilation sheet **71** are provided on the upper surface of the container body **50** that faces the conveyance screw **53** in the developer storage **51**. Owing to this configuration, the vent hole **70** and the ventilation sheet **71** are less likely to be clogged with toner, and ventilation property is maintained for an extended period of time.

Even in a case in which toner has been adhered to the ventilation sheet **71**, it is possible to take off the toner from the ventilation sheet **71** by a vibration caused when user detaches or attaches the toner cartridge **26**. In the above-described embodiment, since the gripper **65** is disposed in proximity to the ventilation sheet **71**, a vibration caused upon contact of user with the gripper **65** (i.e., the upper surface recess **66** and the back surface recess **67**) is easily transmitted to the ventilation sheet **71**. Thus, toner adhered to the ventilation sheet **71** can be effectively taken off to recover ventilation property of the ventilation sheet **71**.

In the above-described embodiment, since the ventilation sheet **71** is provided to the bottom surface **66***a* that is the most recessed part of the upper surface recess **66**, even when user drops down the toner cartridge **26** by mistake, the ventilation sheet **71** is less likely to collide with peripheral members to be damaged.

It is also possible to provide a projection **72** to the periphery of the ventilation sheet **71**, as illustrated in FIG. **19**, when there is a possibility that the ventilation sheet **71** is damaged as user unexpectedly touches the ventilation sheet **71**. The projection **72** is thicker than the ventilation sheet **71** in the vertical direction and projected upward from the upper surface of the ventilation sheet **71**. The projection **72** prevents user from touching the ventilation sheet **71**, thereby avoiding damage to the ventilation sheet **71**. The projection **72** can be provided to either the whole or a part of the circumference of the ventilation sheet **71**.

By contrast, when there is no possibility that the ventilation sheet **71** is damaged as user touches the ventilation sheet **71**, the ventilation sheet **71** can be provided to any position which user can touch. For example, as illustrated in FIG. **20**, the ventilation sheet **71** and the vent hole **70** can be provided

on the back side surface **66***d* (gripper **65**) of the upper surface recess **66** to be gripped by user holding the toner cartridge **26**. This configuration allows user directly touching the ventilation sheet **71** with a finger. As a result, a vibration is easily transmitted to ventilation sheet **71**, and toner adhered to the ventilation sheet **71** is easily taken off by the vibration. In addition, the ventilation sheet **71** may be given a color different from that of the container body **50** so as to improve visibility of the ventilation sheet **71** by user.

The vent holes and ventilations sheets having the above-described configurations (as illustrated in FIGS. **14** to **20**) can be applied not only to toner cartridges but also to developing devices (development housings) other powder containers, such as waste-toner container.

Numerous additional modifications and variations are possible in light of the above teachings. It is therefore to be understood that, within the scope of the above teachings, the present disclosure may be practiced otherwise than as specifically described herein. With some embodiments having thus been described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the scope of the present disclosure and appended claims, and all such modifications are intended to be included within the scope of the present disclosure and appended claims.

What is claimed is:

1. A powder container, comprising:

a powder storage to store a powder to be used for image formation, the powder storage having a vent hole to pass air between an inside and an outside of the powder storage; and

a conveyer to convey the powder inside the powder storage,

wherein the vent hole is on an upper surface of the powder storage facing the conveyer,

wherein the powder storage includes:

an upper compartment disposed on an upper part of the powder storage,

a lower compartment disposed on a lower part of the powder storage,

a fall port through which the powder falls down from the upper compartment to the lower compartment, and

a push-up port through which the powder is pushed up from the lower compartment to the upper compartment,

wherein the upper compartment has a supply opening through which the powder is externally supplied, the supply opening passing through the upper surface of the powder storage facing the conveyer, and

wherein the vent hole is downstream from the supply opening relative to a direction of conveyance of the powder in the upper compartment.

2. The powder container of claim **1**, wherein the conveyer includes a conveyance part having a spiral blade and an agitation part having a planar blade, and

wherein the vent hole is upstream from the agitation part relative to the direction of conveyance of the powder in the upper compartment.

3. The powder container of claim **2**, wherein the vent hole is upstream of the planar blade relative to the direction of conveyance of the powder in the upper compartment.

4. The powder container of claim **1**, wherein the vent hole is upstream from the fall port relative to the direction of conveyance of the powder in the upper compartment.

5. The powder container of claim **1**, wherein the vent hole is downstream from the push-up port relative to direction of conveyance of the powder in the upper compartment.

6. The powder container of claim **1**, wherein the vent hole is above the fall port with at least a part of the vent hole overlapping with the fall port in a vertical direction.

7. The powder container of claim **1**,

further comprising a second vent hole above the push-up port with at least a part of the second vent hole overlapping with the push-up port in a vertical direction.

8. The powder container of claim **1**, wherein the vent hole has a first length in a direction of conveyance of the powder and a second length in a direction perpendicular to the direction of conveyance of the powder, the first length being equal to or greater than the second length.

9. The powder container of claim **1**, further comprising a ventilation sheet to cover the vent hole, the ventilation sheet allowing air to pass through while blocking the powder from passing through, the ventilation sheet including an oil-repellent sheet.

10. The powder container of claim **9**, wherein the ventilation sheet has an air-permeable area greater than an aperture of the vent hole.

11. A developing device, comprising:

a developer container to contain a developer, the developer container being the powder container of claim **1**, the developer being the powder to be used for image formation;

a developer bearer to bear the developer; and

a developer supplier to supply the developer from the developer container to the developer bearer.

12. A process unit detachably mountable on an image forming apparatus, comprising:

a latent image bearer to bear a latent image; and

the developing device of claim **11** to develop the latent image on the latent image bearer with the developer.

13. An image forming apparatus, comprising:

a latent image bearer to bear a latent image; and

a developing device to develop the latent image on the latent image bearer with a developer, the developing device including:

a developer container to contain the developer, the developer container being the powder container of claim **1**, the developer being the powder to be used for image formation;

a developer bearer to bear the developer; and

a developer supplier to supply the developer from the developer container to the developer bearer.

14. A powder container, comprising:

a powder storage to store a powder to be used for image formation, the powder storage having a vent hole to pass air between an inside and an outside of the powder storage; and

a conveyer to convey the powder inside the powder storage,

wherein the vent hole is on an upper surface of the powder storage facing the conveyer,

wherein the powder storage includes:

an upper case disposed on an upper part of the powder storage, the upper case having a recess on an upper surface thereof, the upper surface being angled and a bottom of the recess being flat, and

a lower case disposed on a lower part of the powder storage, and wherein the vent hole is on the recess.

15. The powder container of claim **14**, wherein the recess includes:

a bottom surface, and

a back surface, and

wherein the vent hole is on the bottom surface.

16. The powder container of claim **15**, wherein the back surface has a plurality of ribs disposed substantially parallel to a longitudinal direction of the conveyer.

17. The powder container of claim **15**, wherein the back surface of the recess extends vertically from the bottom surface of the recess.

18. The powder container of claim **14**, further comprising a ventilation sheet to cover the vent hole, the ventilation sheet allowing air to pass through while blocking the powder from passing through, the ventilation sheet including an oil-repellent sheet, the ventilation sheet having an air-permeable area greater than an aperture of the vent hole.

19. The powder container of claim **18**, further comprising a projection at a periphery of the ventilation sheet, the projection has a height greater than a thickness of the ventilation sheet to project upward from an upper surface of the ventilation sheet.

20. The powder container of claim **18**, wherein the ventilation sheet has a color different from that of the powder storage.

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